Work-related psychosocial stress and allostatic load within firefighters

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The aim of this study was to investigate the nature and type of psychosocial stress experienced by firefighters through investigating the cumulative effects of work-related factors on their health by reviewing current literature. In addition, the study investigated a range of physiological markers of chronic stress experience (i.e., an allostatic load index), and determined relationships between allostatic load and work-related stressors amongst 6 firefighters.

Results from the systematic review showed the significant role psychosocial stressors played on the health outcomes of the studied firefighters. Psychosocial factors (including social support, job demand/pressure, lack of reward, organizational system, occupational climate/environment, self-esteem, rank of work, shift work, shift work and self esteem) showed various associations with unfavourable health outcomes in firefighters.

The pilot study revealed high perceived stress levels among the sample population. Significant associations were observed between hair cortisol level (stress response) and perceived stress reported by the firefighters. Systolic blood pressure and HbA1c levels also showed a positive correlation with perceived stress. The study population reported significant concern on the following psychosocial factors: organizational structure, clear leadership and expectations, involvement and influence, and workload management.

The allostatic load index (ALI) in our study population was relatively high when compared with other population groups. Certain biomarkers of the ALI surpassed their accepted cut-off levels (systolic blood pressure, BMI and hair cortisol levels). Despite high perceived stress levels and corresponding ALI, we were unable to find a significant association between ALI and workplace stressors in our study population.

Future research should include a longitudinal study with an effective sample size using multi-systemic variables (ALI) to investigate biologic wear and tear associated with firefighting.

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List of abbreviations

ALI – Allostatic Load Index

AUDIT - Alcohol Use Disorder Identification Test

BMI – Body Mass Index

BP – Blood Pressure

CAGE – Cut down, Annoyed, Guilty, and Eye opener

CAPS – Clinician Administered PTSD Scale

CRH – Corticotropin Releasing Hormone

DHEA – Dehydroepiandrosterone

GERD – Gastro-Esophageal Reflux Disorder

HPA – Hypothalamic- Pituitary- Adrenal

HRV – Heart Rate Variability

IBS – Irritable Bowel Syndrome

KOSS – Korean Occupational Stress Scale

LC- NE – Locus Coeruleus Norepinephrine

LT – Lower Tertile

MT – Middle Tertile

NAL – Neuroendocrine Allostatic Load

NIOSH - National Institute for Occupational Safety and Health

PCL-C – PTSD Checklist- Civilian version

PTSD – Post-Traumatic Stress Disorder

SOOS – Sources of Occupational Stress

UT- Upper Tertile

WMSD – Work-related Musculoskeletal Disorder

WHR – Waist-Hip Ratio

CHAPTER ONE

General Introduction and Literature Review.

1.1 Introduction

Chronic diseases are long-lasting human health conditions that develop slowly over time, often follow a progressive course, and can be managed, but rarely cured (Ontario Ministry of Health and Long-term Care, 2007). The US National Center for Health Statistics (2014) also defines chronic diseases as conditions lasting for 3 months, or more. Chronic diseases include, but are not limited to, conditions such as cardiovascular diseases (heart disease and stroke), cancer, chronic respiratory diseases (e.g., chronic obstructive pulmonary disease, asthma), and diabetes (World Health Organization, 2016). These conditions may have a significant negative effect on daily physical and mental functioning as they reduce one's ability to perform everyday tasks, which eventually leads to lowered productivity, and higher health care and economic costs to both the individual and society (Ontario Ministry of Health and Long-term care, 2007).

Over the past century, the global prevalence of all leading chronic diseases has increased and overtaken infectious diseases as the leading cause of morbidity and mortality (Yach et al., 2004). Chronic diseases are now accountable for 63% of deaths worldwide with mortality under age 60 standing at 13% in high income countries and 29% in low income countries (Yach et al., 2004). Further, deaths arising from chronic diseases are projected to rise considerably over the next two decades (Yach et al., 2004). Public Health Agency of Canada (2016) estimates that one in five adults in Canada suffer from at least one chronic disease, and that these figures are estimated to rise due to an increasing number of Canadians over the age of 65. An estimated 153,000 deaths are recorded each year in Canada due to 4 types of chronic diseases: cardiovascular diseases, cancer, diabetes and chronic respiratory diseases (Mirolla, 2004). Coupled with the staggering mortality rates, the burgeoning healthcare costs present a big burden. A report from 2002 put the

economic cost of managing the seven major chronic diseases (cardiovascular diseases, chronic obstructive respiratory diseases, cancers, mental illness, endocrine diseases, diseases of nervous system/sense organs and musculoskeletal diseases) at 38.9 billion Canadian dollars in direct healthcare costs (spending on hospitals, doctors, research, and drugs) and 54.4 billion Canadian dollars in indirect costs due to disability and lost productivity (Mirolla, 2004).

In recent times, considerable effort has been made by the medical and research communities to identify and understand the complexities and interrelated causes of the rising prevalence of chronic degenerative diseases. As the epidemiologic transition theory explains, due to increased hygiene, better diagnosis and improved treatment, we have moved past the age of infectious and parasitic diseases to the age of chronic disease (Caldwell, 2001). Individuals are more likely to live longer lives, but also face increased morbidity and mortality from chronic degenerative diseases. What could be the underlying factor driving this trend? Why are more individuals predisposed to developing chronic diseases? Overwhelming evidence points towards increased stress as one of the main contributing factors (Chandola et al., 2006; Goldstein & McEwen, 2002; Mohd, 2008; Vanitallie, 2002). Changing social determinants of health (social and economic), and increasing occupational workload, all contribute to elevated stress levels in society (Crompton, 2011; Danielsson et al., 2012; Mohd, 2008; Williams & Cooper, 1998).

The term “stress” has no universally accepted definition. Commonly, stress usually refers to an event, or succession of events, that evokes a response, usually in the form of “distress” (McEwen, 2000). A current conceptualization of stress describes it as any disruption, or threat of disruption, to homeostasis that triggers adaptive responses (physiological and psychological) (Rosmond, 2005). The adaptive response to stress depends on the stressors (stimuli), the stress response and

the individual's state and constitution. Stressors are identified as stimuli that threaten the body's normal functioning (homeostasis), and can be categorized as either physical, or psychological. Examples of physical stressors include various perturbations to the internal environment like anoxia and hypoglycemia, extremes of the external environment (heat and cold) and multifaceted stressors (noxious stimuli, or physical strain like injury or exercise). Psychological stressors target human emotions and give way to fear, anxiety, or frustration (Johnson et al., 1992).

The stress response is the body's attempt at returning to homeostasis (Chrousos, 2009; Griffin & Clark, 2011) and comprises behavioral and physiological processes that work in tandem. The behavioral component of the stress response is geared towards facilitation of neural pathways that prepare the body to cope more efficiently with stressors. Examples of these behavioral responses include heightened alertness, altered cognitive and sensory thresholds, stress-induced analgesia, memory improvement and subdued feeding and sexual behavior (Johnson et al., 1992). The physiological component encompasses all the processes that provide fuel/energy required to deal with the presenting stressful stimuli. The physiological component facilitates transfer of energy substrates from storage sites to the bloodstream and finally to active tissues (the brain and skeletal muscle) taking part in the stress response, in addition to a cascade of changes to the cardiovascular, endocrine, and immune systems (Johnson et al., 1992; Schneiderman et al., 2005).

An integral part of the physiological stress response is the release of neuroendocrine hormones as well as certain cytokines, growth factors and various neurotransmitters. In the event of a stressful stimulus, two important components of the general adaptation response are activated: the hypothalamic-pituitary adrenocortical axis (HPA) and the locus-coeruleus-norepinephrine (LC-NE)/sympathetic nervous systems (SNS) (Chrousos & Gold, 1992). The paraventricular nucleus,

located in the hypothalamus, produces corticotropin releasing hormone (CRH), which stimulates a cascade of adaptive reactions to stressful stimuli. Release of CRH activates the pituitary-adrenal axis where adrenocorticotropin is produced in the anterior pituitary, which then triggers the secretion of cortisol from the adrenal cortex. Simultaneously, activation of the LC-NE/SNS results in the production of catecholamines (norepinephrine and epinephrine) from the adrenal medulla (Chrousos & Gold, 1992; Schneiderman et al, 2005). The combined effect of catecholamine and cortisol results in increased energy sources as gluconeogenesis and lipolysis are activated. In addition to these changes, the accompanying elevated blood pressure ensures redistribution to organs that need it most, while inhibiting vegetative functions such as feeding and reproduction (Chrousos & Gold, 1992).

Changes in the immune system also accompany the increased availability and redistribution of energy in response to a stressful situation. Leukocytosis is enhanced by the release of cells of the innate immune system (macrophages, natural killer cells) into the blood stream, where these cells then migrate to tissues that are susceptible to damage during a stressful encounter (Schneiderman et al., 2005).

Human beings constantly encounter stressors, with the stress response varying from person to person (McEwen & Stellar, 1993). Research has shown that a wide variety of factors come into play in determining the stress response. These factors are a combination of the types of stressors (acute or chronic) and individual characteristics, such as age and state of health, before the emergence of the stressor. Other factors, such as personality type, genetic vulnerability, coping

style, adverse childhood experiences, and social support, also play an important role in mediating the stress response (Schneiderman et al, 2005; Mohd, 2008).

Having the ability to mount a stress response is an integral part of life and has been shown to be beneficial over the short term. The time-sensitive nature of each stress response makes the anabolic, catabolic, and immunosuppressive effects arising from it advantageous for the time being. However, excessiveness and continuous activation of stress systems and its pathways results in an increased susceptibility to illness and a syndromal state with both negative somatic and behavioral consequences (Chrousos & Gold, 1992; Chrousos 2009).

Indeed, over the past several decades, the field of stress physiology has established a clear connection between the excessive application of social stressors and the development of several chronic diseases (Cohen et al., 2007; Chrousos, 2009; Lucassen et al., 2015). Research has shown an association between stress exposure and the development of cardiovascular disease (Merz et al., 2002; Steptoe & Kivimäki, 2013). Similar positive associations have been found between stress exposure and, development/progression of cancer (Kitlinska & Tilan, 2010), increased severity and progression of respiratory illness (Chen & Miller, 2007; Cohen et al., 2012), and diabetes (Streptoe, 2016; Surwit et al., 1992).

1.1.1 Occupational stress and firefighters

Recently, occupational stress and workplace health have become issues of great concern. Occupational stress, or work-related stress, can be defined as psychological experiences and demands (e.g., long shift work, excessive work load) in the workplace that result in short-term strains and long-term alterations in mental and physical health (Ganster & Rosen, 2013). A

growing body of research has identified a significant association between occupational stress and chronic disease development (Quick & Henderson, 2016).

Several occupational groups come with a greater risk for development of chronic diseases. These groups have higher exposure to a combination of occasional acute stress (severely demanding in nature) and chronic accumulated stress encountered daily (milder, but with frequent occurrence) (Larsson et al., 2016). A prominent group in this sphere are the first responders (e.g., firefighters, EMTs, police officers, and military personnel).

First responders, in general, are often exposed to complex situations on the job, are increasingly more stressed than non-emergency workers, and may face potentially life-threatening injury or death (Fisher & Etches, 2003). Firefighters, in particular, may experience a notable degree of occupational stress (Fisher & Etches, 2003; Jahnke et al., 2016; Plat et al., 2016; Shantz, 2002), which, when considered with the consequences to health and the economic cost to society, is worrisome. Firefighters encounter a wide range of workplace stressors that can be categorized into two main broad groups according to the complex stress model (Fisher & Abrahamson, 2001): traumatic workplace stressors and systemic/specific psychosocial challenges. Traumatic workplace stressors include all fire-related injuries and common risks like structural collapse, equipment failure, exposure to contaminants from products of combustion, motor vehicle accidents, exposure to blood-borne and air-borne diseases, and threats of patient violence. In addition, firefighters are frequently exposed to critical incidents which puts them at risk for vicarious trauma (compassion fatigue) and Post-Traumatic Stress Disorder (PTSD) (Fisher & Etches, 2003). Vicarious trauma consists of all acute and cumulative distress normal individuals experience because of witnessing or hearing other peoples' harrowing situations. Examples

include dealing with victims of fire, accident, and disasters and witnessing injury to or death of victims or firefighter colleagues (Fisher & Etches, 2003).

The other type of occupational stressors firefighters encounter are psychosocial workplace stressors. These have been identified as an important risk factor for chronic disease development (Griep et al., 2015). Psychosocial stress is best described as stress experienced as a result of social interaction with others. It is a combination of events and work characteristics that affect individuals through a psychological stress (mental and emotional strain) process rather than a directly physical one (Ganster & Rosen, 2013). Psychological stress differs from psychosocial stress as it focuses upon individual factors that may influence the mental behavior of a person, whereas psychosocial stress also takes into account various factors from broader society that may affect the mental behaviour of a person. The organizational and systematic structure of the firefighting service provides an environment wherein psychosocial workplace stressor may thrive. Examples include an excessive and punishing workload, overtime, rotating shift work, resource scarcity, work-life conflict, and perceived lack of control, autonomy and decision latitude (An et al., 2015; Fisher & Etches, 2003; Kim et al., 2016; Lee et al., 2017). At the same time, social and systematic changes have increased pressure on firefighting departments. Changing demographics in both staff and community, retraining, increased dependence on sophisticated technology, chronic understaffing, budget slashing, and increased media scrutiny are among the common challenges (Fisher & Etches, 2003). Finally, the peculiar nature of firefighting engenders an atmosphere of social isolation. The paramilitary and hierarchal structure of power and command within the firefighting service encourages a hyper-masculine mentality, and often tends to stigmatize individuals suffering from

stress effects (Beaton & Murphy, 1993). At a psychological level, this unique challenge may lead to more stress, alienation, and stigmatization (Fisher & Etches, 2003).

Given the repeated exposure to workplace stress in the firefighting service, it is no surprise that firefighters face a higher risk of a wide range of negative physiological, mental health, behavioral and interpersonal challenges (Fisher & Abrahamson, 2002). Long-term effects of this exposure increase susceptibility to chronic disease development. McEwen and Stellar's (1993) "Allostatic load model" provides a possible explanation for the cumulative biological impact (organ disease) of chronic exposure to psychosocial stressors. The allostatic load model explains the cumulative physiological consequences of chronic stress adaptation, including wear and tear due to continuous exposure to psychosocial stressors (Mauss et al., 2015).

1.2 Study rationale

To date, research in the field of occupational ergonomics and stress has identified a possible connection between chronic exposure to psychosocial workplace stressors and development of chronic disease with time (Bellingrath et al., 2009; Ganster & Rosen, 2013; Mauss et al., 2015; Sun et al., 2007). However, stress research within first responders (particularly, firefighters) is saturated with studies focused on outcomes relating to acute conditions (e.g., physical injuries, acute stress disorders) and traumatic stress outcomes like PTSD (Armstrong et al., 2014; Jahnke et al., 2016; Katsavouni et al., 2015; Shantz, 2002; Susan & Frederick, 2000). However, very little has been done to clearly define the effect of psychosocial stressors on firefighters and the long-term effect with regards to allostatic load on their health. Therefore, the main goal of my research will be to address this clear knowledge gap.

The major goal of my research will be to provide an improved understanding of the psychosocial stress encountered by firefighters, and how these experiences may become biologically embedded in such a way as to increase the possibility of developing a range of chronic diseases. To achieve this goal, the proposed study will meet the following objectives:

1. Determine the types of psychosocial stressors experienced by firefighters by investigating work-related factors and their effects on health in the form of a systematic review.
2. Collect a range of physiological markers of chronic stress experience (allostatic load) and determine relationships between this allostatic load and psychosocial stress in a cohort of firefighters in the form of a pilot study.

1.3 Organization of the thesis

The thesis consists of 4 chapters. The first chapter provides a background and literature review of current state of firefighter health and provides the rationale for the project. Chapter two reviews existing literature regarding psychosocial factors and how they affect firefighter's health. Chapter three is made up of a pilot study that investigates work-place stressors and allostatic load in a cohort of active firefighters from the Waterloo fire-service. The third chapter consists of a literature review, study rationale, research design and methodology, and ethical consideration. Results are discussed in detail and a conclusion drawn. The key findings from both chapter two and three are further discussed in chapter four. A general conclusion is drawn followed by limitations and recommendations that have emerged from this study.

CHAPTER TWO

The Effect of Psychosocial Stress on the Health of Firefighters: A Systematic Review.

2.1 Introduction

Firefighters perform a range of functions including prevention and suppression of fire, disaster recovery, and more recently, emergency medical services. Due to the nature of these tasks, firefighting ranks high amongst the most stressful and dangerous occupations. For example, a 2016 Forbes Magazine article ranked firefighting as the second most stressful occupation after active military service (Career Cast, 2016). In recent times, occupational stress and workplace health within firefighting have become issues of great concern. Importantly, the occupational stress specific to firefighters can be described as resulting from psychological experiences and demands in the workplace (e.g., long shift work, excessive workload) that leads to short-term strains and long-term mental and physical health changes (Ganster & Rosen, 2013).

Psychosocial workplace stressors, a subset of occupational stressors, have gained attention lately, and are the focus of this review. Psychosocial stress is best described as a combination of events and work characteristics that affect individuals through a psychological stress process (mental and emotional strain) rather than a directly physical one (Ganster & Rosen, 2013). The organizational structure of urban firefighting provides an environment for psychosocial and systemic workplace stressors. Some of these stressors include excessive workload, rotating shift work, resource scarcity, social isolation, inadequate social support, work-life conflict, interpersonal/organizational conflict, job insecurity and perceived lack of control, autonomy and decision latitude (Beaton et al., 1998; Fisher & Etches, 2003; Kim et al., 2016). In addition, systemic and social changes add to the growing list of psychosocial stressors within firefighting departments. Examples include retraining on sophisticated technology, changing demographics in

both staff and community, chronic understaffing, budget restriction, and increased media scrutiny (Fisher & Etches, 2003).

Psychosocial stressors within the workplace can have negative influence on the health of an individual regardless of company size, area of expertise, or their position within the company. Chronic exposure to psychosocial stressors can lead to fatigue, burnout, and consequently, chronic diseases within the workforce (Griep et al., 2015; Quick & Henderson, 2016). Burnout might also serve as an underlying factor for chronic disease development (Langelaan et al., 2007). Burnout can produce an array of changes: (a) physiological dysfunction (i.e., cardiovascular changes, immunosuppression, and "stress-related" illnesses), (b) psychological dysfunction (e.g., anxiety, depression, lethargy), and (c) behavioral dysfunction (e.g., unhealthy diets and habits, absenteeism) (Guglielmi & Tatrow, 1998; Salvagioni et al., 2017). Similarly, chronic diseases (cardiovascular, musculoskeletal, gastrointestinal/metabolic, mental disorders), sleep disorders and unhealthy behavioral habits (smoking, alcohol/drug dependence or/and abuse) have been linked with exposure to psychosocial stressors (Peltzer et al., 2009; Rutters et al., 2014).

Putting into perspective the magnitude and frequency of duty-related exposures to psychosocial stressors, it is paramount to investigate the various and unpredictable effects of these stressors on the general health of firefighters. To date, research investigating the health of firefighters has largely focused on traumatic workplace stressors, and the effect of exposures to critical incidents particularly in relation to post-traumatic stress disorder (PTSD) given the most attention (Berger et al., 2012; Meyer et al., 2012). However, research into the effect of psychosocial stressors on first responders, especially firefighters has begun to grow in recent times, as a result, there is a need to identify, evaluate, and synthesize the evidence.

2.2 Purpose of Review

With the recent growth in research surrounding the health of firefighters and various factors leading to chronic disease within this population, it is important to address the often-neglected effect of psychosocial stressors on this group. Therefore, the objective of this review was to identify and synthesize existing research on the multifactorial effect of psychosocial stressors on the health of firefighters. The following key question will be answered: *by investigating the existing literature, can we identify the psychosocial stressors experienced by firefighters and the health outcomes associated with these stressors?*

2.3 Methodology

2.3.1 Search strategy and selection criteria

A review of the literature was carried out by one of the researchers (SI) employing a strategy conceived by all of the authors. Databases searched included: PubMed, CINAHL, and PsychINFO. MeSH terms and author keywords, such as *stress, psychosocial stress, firefighters, burnout, and emotional disorders,* were used (detailed description of the search strategies can be seen in the appendix). In addition to the electronic database search, reference lists from screened articles were scanned for additional studies of relevance to the topic.

Prior to beginning the search, a protocol outlining the eligibility criteria and extraction procedure was developed. For inclusion, published articles were required to have (1) been published in English language, (2) involved firefighters, (3) specifically focused on psychosocial stressors, (please see below for further information on this point), and (4) reported on health outcomes. Although many studies investigated a mix of different occupational stressors pertaining to firefighters, and the majority of the studies focused on traumatic workplace stressors, we focused on those that used psychosocial stressors and measured its impact on the health of firefighters via validated and invalidated questionnaires.

Chronic health conditions were the outcome of interest for this review. Therefore, any article that reported on chronic health conditions, both mental and physical was included for further assessment. Studies that investigated psychosocial stressors without a resultant health outcome were excluded. Further, systematic reviews, conference proceedings and editorials were excluded. Duplicates were identified and removed using a RefWorks database. Articles meeting eligibility

status underwent full-text review, with their accompanying reference list further perused for additional articles not present in the original search. A detailed review was carried out by the main reviewer (SI) in consultation with the other reviewer (JM).

2.3.2 Data extraction and analysis

The Cochrane Consumers and Communication Review Group data extraction template was adopted as a guide for developing a template for data extraction from the studies of interest (Ryan, 2013); information on study location and design, observed outcomes (i.e., chronic diseases, both physical and mental), and psychosocial stressors measured using different questionnaires, were gathered. During the analysis, a noticeable degree of methodical heterogeneity was observed in the eligible articles, in particular there was clear variation in study design, data collection methods and outcomes. As a result, data were not considered appropriate for a meta-analysis, but, instead, were thematically analysed according to health outcomes (e.g., mental, somatic diseases)

For this review, studies that used validated questionnaires with a measurable degree of reliability and validity were regarded as a good quality study while those measuring psychosocial stressors with an invalidated questionnaire or via direct questioning were rated as poor quality. Two reviewers (SI and JM) independently looked at these criteria for each study and settled any disagreements by consensus.

2.4 Results

2.4.1 Study and sample characteristics

The literature search returned 891 article titles, which were subjected to further screening for eligibility. After going through titles and abstracts, we eliminated duplicates and those studies missing the criteria for inclusion, which left 94 studies for a full-text review. Subsequently, 20 studies investigating psychosocial stress and associations with firefighter's health outcomes were included in this review. Figure 1 outlines the strategy used to select the articles that formed the basis of the review.

Table 1 summarizes the eligible study characteristics which include the first author, year of publication, country where the study was carried out, study design, sample size, questionnaire used for psychosocial stress measurement, the health outcomes examined and the findings. Regarding quality assessment, 3 studies used non-validated questionnaires with no psychometrics properties reported. The rest (17/20), used a validated scale and reported adequate psychometric properties.

A majority of the studies used a cross-sectional study design, with only two using a longitudinal study design. Most of the studies came from Asia (12/20), followed by North America (6/20), and South America and Europe with one each. The total number of participants investigated across the studies was 58,563 with sample sizes ranging from 123-24209 (mean, 2928; standard deviation, 6844). There were 11 mixed studies consisting of both male and female firefighters and 10 studies focused solely on male firefighters. Only one study justified its sample size (i.e., specifying the expected effect size) (Damrongsak et al., 2017). The results were organized according to the health

outcomes reported; for the purposes of grouping, a health outcome had to have been reported in at least two studies.

2.4.2 Psychosocial stressors and behavioral/mental health disorders

We identified 8 studies that reported a significant association between psychosocial stressors and mental health disorders in firefighters (Regehr et al., 2003; Mitani et al., 2006; Tak et al., 2007; Saijo et al., 2007, 2008, 2012; Meyer et al., 2012; Ângelo & Chambel, 2013). The following mental health conditions were present: depression, burnout, and PTSD.

Low level of social support was a significant psychosocial stressor associated with depressive symptoms. We observed this finding in three cross-sectional studies where perceived low social support in the form of dissatisfaction with a supervisor (Tak et al., 2007) and inadequate support from employers, family or friend (Regehr et al., 2003; Saijo et al., 2008) was associated with symptoms of depression.

Two studies conducted by Saijo et al (2007, 2008) reported on psychosocial stressors related to the organizational system of the firefighting service. Notably factors such as high intergroup conflict and high role conflict and ambiguity appeared to be significantly associated with depressive symptoms among Japanese firefighters. Similar results were observed in a longitudinal study on 186 municipal firefighters, which showed an 8 fold higher risk for depression associated with poor organizational system (An et al., 2015). Other psychosocial factors, such as low self-esteem related to job dissatisfaction and high variance in workload, also had a significant relationship to depressive symptoms (Saijo et al., 2007; Saijo et al., 2008).

According to the definition by Maslach and Jackson (1981), burnout is a syndrome that includes three dimensions: emotional exhaustion, depersonalization and reduced personal accomplishments. In lay terms, burnout is characterized by a continuous, negative work-related attitude characterized by exhaustion, decreased effectiveness, and low motivation levels observed in "normal" individuals (Kulkarni, 2006). Burnout in firefighters was reported in two studies (Mitani et al., 2006; Ângelo & Chambel, 2013). The first study was conducted to ascertain factors related to burnout (emotional exhaustion, depersonalization and personal accomplishment), and reported that social support showed a significant negative association with emotional exhaustion and depersonalization, and a significant positive association with personal accomplishment (Mitani et al., 2006). The second study was a longitudinal examination of 1610 firefighters, and employed a cross-lagged panel analysis to determine reciprocal relationships between organizational demands and burnout. Results from the study showed a reciprocal positive relationship between organizational demands and burnout (Ângelo & Chambel, 2013).

Direct relationships between psychosocial stressors and PTSD among firefighters was also reported. Low social support was an important stressor associated with symptoms of PTSD among firefighters (Meyer et al., 2012; Mitani et al., 2006; Saijo et al., 2012). Meyer et al. (2012) showed that firefighters belonging to a low-social-support-high-self-blame group were more likely to exhibit clinically significant symptoms of PTSD. Similar results were observed in another cross-sectional study where low social support (from supervisors) among other factors, like high inter-group conflict and role ambiguity, had a significant relationship with the presence of PTSD (Saijo et al., 2012). Mitani et al. (2006) also reported significantly lower social support and a high self-administered job stress in the PTSD high-risk group among 243 participating firefighters.

For behavioral disorders, alcohol dependence was reported in a study evaluating the association between psychosocial stressors and behavioral outcomes within the workplace. Among psychosocial stressors measured, poor workplace environment (inadequate support during emergency/rescue operations and high office workload) and lower rank of work showed a significant association to alcohol dependence (Hosoda et al., 2012). Low social support was linked to alcohol abuse among firefighters. In one study, firefighters who were part of a low social support-high blame group were significantly more likely to report alcohol abuse on the CAGE questionnaire for detecting alcoholism (Meyer et al., 2012).

2.4.3 Psychosocial stressors and Sleep disorders

Three studies investigated the association between various work-related stressors and sleep disorders among firefighters (Barros et al.,2012; Haddock et al., 2012; Lim et al., 2014). The dominant theme was shift-related problems. For example, a study by (Lim et al., 2014) reported that psychosocial stressors, such as shift work, increased job demand, insufficient job control, job insecurity, organizational system, lack of reward, and occupational climate were significantly related to poor sleep quality. However, after conducting a multivariate logistic analysis that considered other factors (e.g. depression, age, alcohol intake and occupational stress), shift work was the only psychosocial factor significantly associated with poor sleep quality. Further, another study showed that firefighters who worked longer shifts (48-h) were significantly more likely to experience excessive daytime sleepiness (EDS) compared to their counterparts who worked 24 hour shifts (Haddock et al., 2012). However, conflicting results were observed in Barros et al. (2012) study, where shift work had no significant association with sleep disturbances among Brazilian military firefighters.

2.4.4 Psychosocial stressors and somatic disorders

2.4.4.1 Cardiovascular disorders

We found one study that investigated the association between number of 24 hour shifts in a month with elevated diastolic blood pressure (DBP) in a cohort of American male firefighters (Choi et al., 2016). In particular, firefighters reporting sixteen 24-h shifts in a month had a higher 5.0 mmHg DBP compared to their counterparts working a standard work schedule (eight to eleven 24-h shifts). This observation was not mediated by health-related behaviors (eating, exercise, sleep hours), psychological distress and PTSD. In addition, an increased job demand (excessive amount of work and conflicting demands) was associated with 3.0 mmHg higher systolic blood pressure (SBP) among firefighters who reported this stressor (Choi et al., 2016). Heart rate variability (HRV), a measure of periodic variation of heart rate over time and a predictive clinical tool for risk of sudden cardiac death and arrhythmias was investigated in a group of firefighters with high job stress (Shin et al., 2016). After adjusting for job characteristics, occupational climate (job conflicts, authoritative and vertical workplace atmosphere) and a poor organizational system (unfair policies and unsatisfactory organizational support) were associated with a decrease in HRV which signifies a higher risk for cardiovascular failure (Shin et al., 2016).

2.4.4.2 Musculoskeletal disorders.

Among work-related musculoskeletal disorders (WMSDs) experienced by firefighters, back pain was the most common complaint. Kim et al. (2013) investigated WMSDs among South Korean firefighters, and revealed that back pain followed by neck complaints were the most common WMSDs, especially among firefighters performing emergency medical services. At the same time,

the study revealed certain psychosocial stressors were associated with these WMSDs, including**:** lack of reward, poor organizational system, job insecurity, hostile occupational climate, high job demands and uncomfortable physical environment after adjusting for depression and general characteristic (e.g., job class, exercise). Similar findings were observed in Kim et al. (2016) and Damrogsak et al. (2017) who found that psychosocial factors were significantly associated with the occurrence of back pain in both study population. In the Kim et al. (2016) study, psychosocial stressors included an uncomfortable physical environment, high mental job demand and organizational system (injustice) after controlling for general characteristics, life-style and work-related factors. At the same time, adequate social support was found to be inversely associated with back pain. The Damrogsak et al. (2017) study found occupational stress (i.e., increased job pressure and lack of organizational support) to be a significant predictor of back pain.

2.4.4.3 Gastrointestinal disorders

Two studies investigated gastrointestinal outcomes among a cohort of firefighters in South Korea who reported various psychosocial work-place stressors(Jang et al., 2016, 2017). The first study focused on gastroesophageal reflux disease (GERD) and revealed that subjects with GERD symptoms reported high psychosocial stress scores. Demand-reward imbalance, interpersonal conflict, and occupational climate were all associated to an increased GERD risk after adjusting for age of the subjects (Jang et al., 2016). The other gastrointestinal outcome investigated was irritable bowel syndrome (IBS). According to Jang et al. (2017), increased risk for IBS was associated with job demands, organizational system, interpersonal conflict, and lack of reward after adjusting for age.

2.5 Discussion

2.5.1 Main findings of the study

The aim of this systematic review was to identify and synthesize existing research on the types of psychosocial stressors experienced by firefighters, as well as their related health outcomes. Not surprisingly, the majority of studies dealt with mental health and behavioral outcomes as a result of exposure to psychosocial stress. A meta-analytical review focusing on psychosocial work environment and mental health found robust and empirical evidence supporting exposure to psychosocial stressors prospectively increased the risk of common mental disorders (Stanfeld & Candy, 2006). In our review, we found depression, PTSD and burnout were the prevalent mental disorders linked to psychosocial factors.

Lack of social support was a recurring factor related to all three mental health disorders (depression, burnout and PTSD). As levels of perceived support decreased, be it support from employer, supervisor, family, and friends, symptoms of depression increased. These findings are consistent with previous studies that have explored the effect of social support on depression in the general population (Brummett et al., 2003; Park et al., 2004). In the case of PTSD, findings regarding positive association with low social support, reinforce the view that lower levels of perceived social support might amplify the risk for posttraumatic psychopathology by impacting interpretation of potentially traumatic events (Meyer et al., 2012). Social support also had a buffering effect on suicidal ideation, as firefighters with low social support when exposed to stress, showed a positive significant association with suicidal ideation (Carpenter et al., 2015).

A potential reason for lack of social support within the fire service might be linked to the nature of the job of firefighters. For example, the paramilitary structure of power and command within the firefighting service encourages a hyper-masculine mentality, and may stigmatize individuals suffering from stress effects (Beaton & Murphy, 1993). This may directly or indirectly lead to an inability of firefighters seeking for support. At a psychological level, this unique challenge may lead to difficulty in communication and further alienation, which eventually worsen the perceived lack of support (Fisher & Etches, 2003). At the same time, due to the nature of shift work, firefighters might struggle to maintain strong social support outside of the workplace (Regehr et al.,2003).

According to the KOSS (Kang et al., 2015), an "organizational system" may evoke psychosocial stress through unfair organizational policy, organizational injustice, intra- and intergroup conflict, unsatisfactory organizational support, and limited communication. According to our findings, a firefighter organizational system may play a significant role in all three mental health outcomes (depression, burnout, and PTSD). An overwhelming organizational system will create an environment where other psychosocial stressors like, increased job/organizational demands, might fester, further worsening mental health outcomes, especially burnout. Other factors that showed significant association to mental health outcomes included low self esteem (depression), and role ambiguity (PTSD)

With regards to unhealthy habits, alcohol abuse/dependence was prevalent among studied firefighters. Meyer et al. (2012) assessed alcohol use via the CAGE questionnaire, while Hosoda et al. (2012) measured hazardous drinking on the Alcohol Use Disorder Identification Test (AUDIT). Both studies reported an association between alcohol use and exposure to psychosocial

stressors. Poor Workplace environment, low rank of work, and low social support were all linked to higher risk for alcohol consumption and dependence. Due to the cross-sectional nature of both studies investigating the association between alcohol abuse/dependence and exposure to these stressors, causal relationships could not be determined. However, regarding rank of work, (Hosoda et al., 2012) explained that lower ranked personnel might be exposed to more workload and longer work hours, making them more likely to consume alcohol to cope. Also, psychological responses to these psychosocial stressors may lead to distress and distress-related sequalae, such as helplessness and inability to cope. In an attempt to "escape" from the immediate distress, firefighters might engage in short-term fixes, like drinking (Bacharach et al., 2008).

Shift work played a significant role in sleep disorders. Both studies (Haddock et al., 2012; Lim et al., 2014) reported a significant link between shift work and sleep disorders. The effect of shift work and longer shifts is detrimental to firefighters' health and wellbeing. Shift work affects the circadian rhythm leading to circadian misalignment and physiological malfunction that reduces quality of sleep and causes sleep disorders (Lim et al., 2014; Barger et al., 2015). Also, circadian misalignment that accompanies shift work may increase the risk of depression among firefighters (Barger et al., 2015). As studies have shown, depression and sleep disorders show mutual causality as depression is well known to cause insomnia (Lim et al., 2014; Barger et al., 2015). In general, inadequate coping with psychosocial stressors can lead to mental and physiological hyperarousal resulting in sleep difficulties and fear associated with sleeplessness. Eventually, activity of these factors leads to a "vicious cycle" that further extends insomnia (Barros et al., 2012).

Exposure to psychosocial stressors places firefighters at an increased risk of experiencing physical disease. In particular, our review shows that cardiovascular, musculoskeletal and

gastrointestinal disorders maybe related to psychosocial factors. Regarding cardiovascular disease (CVD), poor organisational system, increased job demands, shift work and occupational climate played significant roles. Unreasonable organizational system was associated with elevated total cholesterol level, pulse wave velocity, and a decreased heart rate velocity. In addition, psychosocial stressors reduce HRV by stimulating sympathetic nervous system (SNS) and degrading parasympathetic nervous system (PNS). This phenomenon leads to development of CVDs via vessel wall thickening and increased vascular resistance (Shin et al., 2016). A similar mechanism is observed with additional 24-h shifts and an increase in BP. Circadian misalignment caused by additional 24-h shifts may increase mean arterial BP by elevating total peripheral resistance, cardiac output, or blood volume (Choi, et al., 2016).

Back, neck and foot pain were the reported WMSD related to psychosocial stressors. Back pain was the most commonly investigated WMSD. Poor organizational system, uncomfortable physical environment, high job demands/pressure, lack of reward, occupational climate, and job insecurity were the psychosocial factors associated with WMSD. Psychosocial stressors increased job-related psychological burden and stress, which may activate a cascade of events that includes an increased muscle tone leading to fatigue, slower recovery, intensification of pain perception, weakened pain coping mechanisms, increase muscle activity, and diminished circulation and supply of oxygen to tissues (Visser & Diee, 2006 ; Kim et al., 2013).

Psychosocial factors exerted a substantial effect on irritable bowel syndrome (IBS) and gastro-intestinal reflux disease (GERD) in firefighters. Irritable bowel syndrome, a prevalent functional gastrointestinal disorder, is characterized by a “chronic, relapsing abdominal pain or discomfort and disordered defecation” (Jang et al., 2017). Psychosocial stressors affecting both conditions

were similar, and they included job demands, lack of reward, and interpersonal conflict. A poor organizational system was peculiar to IBS, while an unfavourable occupational climate affected GERD. Possible mechanism underlying psychosocial stress association with IBS is a dysregulated gut-brain axis. The gut microbiome may be responsible for the onset and exacerbation of symptoms of this disorder (Jang et al., 2017). In the case of GERD, a reduction in gut motility and increased sensitivity to GERD in a state of stress may be the underlying cause (Jang et al., 2016).

2.5.2 Limitations of the current review

A few methodological considerations should be noted. Due to our inclusion of only articles published in English, there is a possibility that we missed relevant research. Also, since we only used published studies, a source selection (i.e., publication bias) may have affected our study. Furthermore, a majority of the included studies were based on a retrospective cross-sectional design; therefore, findings should be considered in light of inherent methodological weaknesses. Considerations should also be given to heterogeneity regarding the measures used in appraising psychosocial stress among firefighters. The questionnaires used varied mainly according to geographical settings and needs, thereby giving different definitions and measures of psychosocial stressors. In light of the mentioned limitations, our findings should be considered cautiously.

2.6 Conclusions and implications for research and public health

To our knowledge, our systematic review was the first of its kind to identify psychosocial stressors encountered within the fire-service and their contribution to related health outcomes. Our review identified various psychosocial stressors linked to various unfavourable outcomes in mental, behavioral, cardiovascular, gastrointestinal, musculoskeletal and sleep health. The following psychosocial factors showed a significant association with the health outcomes stated earlier: organizational system, social support, shift work, occupational climate, job demands, physical environment, interpersonal conflict, and lack of reward.

In a bid to further understand the nature of the relationships at play, further research focusing on an effective definition and measurement of psychosocial stressors should be conducted. Also, a validated questionnaire with broad appeal that serves as the gold standard to appraise psychosocial stress among firefighters should be adopted. In addition, a notable finding from our review is the lack of prospective studies. Prospective studies make it easier to draw conclusions regarding the etiological relationships between studied variables (exposure and outcomes). Therefore, additional prospective studies based on clear theoretical framework should be conducted urgently to provide evidence of causal relationships and possible biological pathway.

With regards to public health, findings from this review strongly suggest that psychosocial factors play a role in the etiology and prevalence of negative health outcomes among firefighters. While there are still reservations regarding the quality of evidence on psychosocial stressors and related health outcomes, interventions addressing psychosocial risk factors within the fire service could help mitigate unfavourable health outcomes. Policy that encourages stress awareness and

relief, training to identify stressors, social support at all levels and favourable organizational system should be considered.

CHAPTER THREE

Occupational stress and its effect on allostatic load in firefighters.

3.1 Literature Review

3.1.1 The physiological embedding of stress: Allostatic load

Several occupational groups experience a greater risk for development of chronic diseases. These groups have higher exposure to a combination of occasional acute stress (severely demanding in nature) and chronic accumulated stress encountered daily (milder, but with frequent occurrence) (Larsson et al., 2016). A prominent group in this sphere are the first responders (e.g., firefighters, EMTs, police officers, and military personnel). Firefighters, in particular, may experience a notable degree of occupational stress (Fisher & Etches, 2003; Jahnke et al., 2016; Plat et al., 2016; Shantz, 2002).

Firefighters encounter a wide range of workplace stressors that can be categorized into two groups traumatic workplace stressors and systemic/specific psychosocial challenges (Fisher & Etches, 2003). Psychosocial workplace stressors have been identified as important risk factors for chronic disease development (Bongers et al., 2006; Kivimäki et al., 2006; Siegrist & Rödel, 2006; Niedhammer et al., 2014; Griep et al., 2015). The organizational structure of the firefighting service can provide an environment wherein psychosocial workplace stressors may thrive. Examples include a high job demand and workload, overtime, rotating shift work, lack of social support, work-life conflict, and perceived lack of control, autonomy and decision latitude (Beaton et al., 1997; Fisher & Etches, 2003; An et al., 2015; Kim et al.,2016; Shin et al., 2016; Lee et al., 2017). Given the repeated exposure to these psychosocial stressors, firefighters are highly susceptible to a wide range of negative physiological, mental health, behavioral and interpersonal challenges (Fisher & Etches, 2003).

McEwen and Stellar's (1993) "Allostatic load model" provides a possible explanation for the cumulative biological impact of chronic exposure to psychosocial stressors. The advent of the allostatic load model followed the stress-response work of Selye (1955). Selye's argument centered around stress being the nonspecific response of the body to a demand, regardless of the condition (pleasant, or unpleasant) brought about by the demand. Also, Selye's model of stress response was based on the concept of homeostasis, which was conceived by Walter Cannon, and was originally an expansion of the Claude Bernard's "milieu interieur" theory (principle of a dynamic internal physiological equilibrium). The concept of homeostasis can be described as the maintenance of a complex harmonious equilibrium, which is constantly subjected to, or threatened by intrinsic and extrinsic forces, or stressors that are disruptive (Chrousos, 2009). This steady state, or equilibrium is required for successful adaptation and is preserved by adaptational responses (counteracting and re-establishing forces) that consists of mental/physical reactions that curbs the effect of stress in a bid to maintain the status quo (Chrousos et al., 1992). Therefore, homeostasis ensures that physiological parameters, such as blood pressure, blood glucose and intracellular osmolarity, are kept within a certain preferred set-point by checking any deviation of a set-point via physiological responses aimed at maintaining the optimal level (Koolhaas et al., 2011). However, subsequent research showed that there were no definite set points required to maintain stability of the internal environment; rather, organisms displayed a wide range of behavioral and physiological responses to stressors, and response to demands were achieved by frequently adopting new set points of physiological system (Romero et al., 2009; McEwen & Wingfield, 2010). With these findings, the homeostasis model was inadequate to clearly elucidate the stress response and has been widely replaced with Sterling and Eyer's (1988) "concept of allostasis".

Allostasis (stability through change) refers to integrative adaptive processes that maintain stability through physiological, or behavioral change (Sterling & Eyer, 1988; McEwen & Stellar, 1993; McEwen, 1998). The concept of allostasis highlights the constant dynamism of internal physiologic systems, as it emphasizes the need for progressive adjustments of the internal physiologic environment, with systems displaying varying levels of activity when responding and adapting to environmental demands to achieve healthy functioning (Seeman et al., 1997). The allostasis concept of dynamism of internal physiological regulation differs from the earlier viewpoint of the homeostasis model that held a more static view of the importance of maintaining a stable environment (a state whereby all physiologic parameters are kept within relatively "normal" values) as a mark of optimal functioning (Juster et al., 2016). Therefore, with allostasis, emphasis is placed on optimal operating ranges of the physiological system rather than optimal set points as essential to the homeostasis model (Seeman et al., 1997).

To maintain optimum functioning in the face of stressful stimuli, allostatic systems necessary change the level of physiological activities needed to respond adequately and successfully to demands placed by the stimuli (Seeman et al., 1997). These initial responses play an adaptive role as they provide preparation to cope with demands (Ganster & Rosen, 2013). However, chronic activation of allostatic effectors, and/or excessive responses of this nature, can synergistically affect cellular activities resulting in changes (primary effects) that can adversely disrupt the integrity of physiological systems and ultimately produce disease (Seeman et al., 1997; Mauss et al., 2014). For example, while short term suppression of the immune system by stress hormones can be beneficial, as it reduces the chances of an excessive inflammatory response to an injury, with time, cortisol-mediated immunosuppression weakens the body's defense against infection

(McEwen, 1998). A more disease-specific example is the case of an individual developing chronic hypertension due to a constant remodeling of the cardiovascular system to cope in a stressful environment. Over time, events like arterial stiffening, coronary artery calcification, or aneurysms may accompany the constant cardiovascular changes (Juster et al., 2016). Therefore, chronic dysregulation of the allostatic system can give rise to pathophysiological processes that eventually lead to disease states.

The progressive pattern leading up to dysregulation of specific allostatic effectors can be elucidated with the concept of "allostatic states". Allostatic states represent the different response patterns that explain how physiological systems become either over, or under-active (Juster et al., 2016). McEwen (1998) outlines four potential pathophysiological profiles that illustrate allostatic states. The first profile constitutes the state of "repeatedly activated response" which presents as a barrage of repeated stressors over a sustained period leading to an elevated release of stress mediators (cortisol, adrenaline). The second state is the "non-habituating response", which is a failed state of habituation or adaptation to repeat stressors that results in an excessive application of stress mediators. This phenomenon is due to the inability of the body to moderate the hormonal stress response to the reoccurring events. The third state is a period of "prolonged responses", which represents the unsuccessful attempt at turning off the stress response or restoring normal circadian functioning. The fourth profile, "inadequate responses" refers to a state of hypoactive stress responses, which might facilitate further potentially harmful physiological processes such as, inflammation. Eventually, the ongoing activities of allostatic states precipitate a compensatory readjustment among the different physiological biomarkers (Juster et al., 2016). The cumulative effect of the adaptive responses by the allostatic systems and the progressive nature of allostatic

states eventually becomes a strain and results in multi-systemic “wear and tear” or allostatic load (Seeman et al., 1997).

Allostatic load refers to “the aggregate physiological consequences of chronic stress adaptation, including wear and tear occurring at cellular and supra-cellular levels within the human body” (Mauss et al., 2015). Allostatic load follows a sequence of events with a key principle being the involvement of multiple mediators of adaptation which are intertwined in a nonlinear network. The different mediators carry out biphasic effects that are regulated by additional mediators, most times in a reciprocal fashion that sets up a domino effect on organ systems in the body (Juster et al., 2016). The first set of mediators released as part of allostasis are the primary mediators which include stress hormones (e.g., cortisol and epinephrine) and their antagonists (e.g., dehydroepiandrosterone; DHEA), in simultaneity with release of pro- and anti-inflammatory cytokines (e.g., tumor necrosis factor and interleukin-10). The primary mediators regulate and exact synergistic effects at the cellular level (enzyme activities, receptor signalling, ion channel transport, and gene expression changes) that compromise the physiological integrity of allostatic mechanisms. The primary effects result in further AL at subcellular and cellular levels described as primary outcomes (Juster et al., 2016).

Eventually, chronic secretion of primary mediators leads to compensation by biological systems via the release of secondary mediators, which are responsible for new set of ranges (set points), to maintain the diminishing tissue and organ function in response to over- and/or underproduction of primary mediators (Juster et al., 2016) Secondary mediators include factors within the cardiovascular (e.g., blood pressure and heart rate), immune (e.g., fibrinogen, c-reactive protein), and metabolic (e.g., glucose, cholesterol, and triglycerides) systems. At instances when these

mediators constantly fall outside of the normal acceptable ranges, secondary outcomes may arise and act as risk factors for mental and physical diseases (Ganster & Rosen, 2013; Mauss et al., 2015). The continuous perturbation of secondary mediator over time results in tertiary outcomes characterized by disease endpoints, such as cardiovascular disease, depression and death (Ganster & Rosen, 2013).

3.1.2 Allostatic Load Index

Health-related effects of stress can be quantified using tools like the allostatic load index (ALI), which was originally created using data from a longitudinal, community-based study of successful aging (MacArthur study; Seeman et al., 1997). The parameters that make up the ALI were selected with the goal of summarizing levels of physiologic activity across a range of important regulatory systems whose activities are associated with high risk for disease development. In addition, they were hypothesized to assess and predict long-term risks for morbidity and mortality. The biomarkers used in the original report included the following primary mediators: serum dehydroepiandrosterone sulfate (DHEA-S; a functional HPA axis antagonist), 12-hour urinary epinephrine and norepinephrine (integrated indices for 12-hour sympathetic nervous system activity), 12-hour urinary cortisol (a measure of HPA axis activity); in addition, the following secondary outcomes were included: systolic and diastolic blood pressure (indices for cardiovascular activity), total cholesterol (TC) and high-density lipoprotein (HDL) (indices of long-term atherosclerotic risk), total glycosylated hemoglobin (measure of glucose metabolism), and waist-to-hip ratio (an index for long-term measure of metabolism and adipose tissue deposition presumed to be as a result of elevated glucocorticoid activity).

More recently, researchers have applied effort to assemble a set of biomarkers that best represent a gold standard for calculating ALI, which has led to different approaches and has provided other combinations of biomarkers. However, the best combination of biomarkers for calculating allostatic load remains debatable, as inclusion of irrelevant variables might increase measurement error and exclusion of relevant variables might have a weakening effect on the predictive value of the ALI (Mauss et al., 2015). The consensus amongst researchers is that ALI should contain at least one variable from the neurophysiologic pathways (primary mediator) and a biomarker with significant predictive power for future diseases (secondary mediator) (Mauss et al., 2015).

A few combinations of allostatic load parameters have been considered. One study measured an index of four neuroendocrine markers, also known as neuroendocrine allostatic load (NAL) (Gersten, 2009). The biomarkers (cortisol, DHEA-S, epinephrine and norepinephrine) were measured in relation to a myriad of life stressors in a cross-sectional survey with over a thousand participants of both genders. The authors initially hypothesized that a stressful life history will positively equate to higher NAL scores irrespective of gender. For the most part, the results did not fully support the hypothesis, as a positive and strong association was only found between elevated NAL scores and the number of reported current life stressors among women. Another study considered six biomarkers (cortisol, epinephrine, norepinephrine, BMI, systolic and diastolic pressure), and aimed to investigate cumulative risk exposure and its effect on allostatic load in young adolescents living in poverty (Evans et al., 2007). The significance of maternal responsiveness ("the reaction to young children mothers display in the context of everyday dyadic interaction"; Bornstein & Manian, 2013) on this association was taken into consideration. Results

showed elevated values of the measured biomarkers (elevated ALI) with cumulative risk exposure only in cases of low maternal responsiveness in young adolescents. A more recent study by Mauss et al. (2015), proposed a model combination termed the "big 5", which included diastolic blood pressure, glycosylated hemoglobin, low-density lipoprotein, waist circumference, and heart rate variability (HRV) measured by root-means square differences of successive R-R intervals. Results from this study provided evidence showing the five variables having the strongest and most significant correlation of all variables to work stress. A replication study using the same set of the "big 5" biomarkers corroborated results from the original study (Mauss et al., 2016).

Generally, to calculate the ALI, values of the various parameters are transformed into a summary score. Each parameter is compared to a set of corresponding predefined cut-off values, and, if a value exceeds the cut off score, or falls within the highest risk quartile (i.e., top quartile for all parameters except HDL and DHEA-S for which the lowest quartile is used), then a score of "1" is assigned. Values falling within the normal range are scored as "0". The summed values give the ALI. Higher overall values indicate higher allostatic load (increased physiological strain), while lower values represent better adaptability to stress (Seeman et al., 2001). Other methods for summarizing ALI data, including the averaging of Z scores and use of criterion cut points, have been employed and yield comparable results (McEwen, 2000).

Both cross-sectional and longitudinal studies have shown that an increased ALI has been linked with numerous stressors in the general population (Mauss et al., 2015). Studies measuring differing numbers of AL parameters in workforces have found existing links between ALI and negative health outcomes (de Castro et al., 2010; Langelaan et al., 2007; Mauss et al., 2015). A systematic review exploring relationships between increased allostatic load and work-related stressors

revealed associations between increasing allostatic load and effort-reward imbalance, low decision latitude, low job control, and low work safety. Health consequences, like exhaustion, burnout and low self-rated health, were associated with increased ALI as well (Mauss et al., 2015).

In addition, a study investigated the relationship between job strain and allostatic load in 1219 healthy industrial employees in China (Sun et al., 2007). For this study, the ALI was made up of 8 items from the original Seeman et al. (1997) 10-item index: systolic and diastolic blood pressure, epinephrine, waist-hip-ratio (WHR), glycosylated hemoglobin (HbA1c), HDL. TC, and urinary levels of cortisol. Five other metabolic parameters were used for this study: fasting insulin glucose ratio (IGR; a commonly used parameter in metabolic research influenced by HPA axis activity), body mass index (BMI), serum triglyceride (TG), fibrinogen (FIB), and c-reactive protein (CRP), all parameters commonly used to investigate health outcomes of job stress. Job strain was assessed using a psychosocial characteristics questionnaire, the Job Content Questionnaire (JCQ). Other variables considered were demographic characteristics and Type A personality characteristics. Results revealed that participants experiencing high job strain exhibited significantly higher AL (elevation of BMI, systolic blood pressure, serum levels of TG, TC/HDL, and cortisol secretion) than those with low job strain (Sun et al., 2007). The findings were similar to those observed by Schnorpfeil et al. (2003) where increased job demands were positively and significantly related to allostatic load score. Both studies suggest that work-related psychosocial stressors might impact multiple organ/system physiological function and present more than one risk factor, thus corroborating the significance of looking at risk factors (stressors) through the broad lens of the allostatic load model.

3.2 Study Rationale

As discussed, research on allostatic load has identified a possible connection between exposure to psychosocial work-place stressors and greater allostatic load index, which, in most instances, leads to development of chronic disease with time (Bellingrath et al., 2009; Ganster & Rosen, 2013; Mauss et al., 2015; Sun et al., 2007). However, there is a clear absence of work that has been done to identify allostatic load within firefighters and the work-related factors that may lead to this type of physiological strain. Therefore, the main purpose of my research was to address a clear knowledge gap by answering the following primary research question, *"Does the occupational stress encountered by firefighters affect their allostatic load?"*.

The proposed study will meet the following objectives:

1. Determine the nature of psychosocial stress experienced by firefighters by investigating work-related factors using a set of validated behavioral questionnaires.
2. Determine a range of physiological markers of chronic stress experience (allostatic load) that will provide a quantitative assessment of the overall effects of stress on the study population.
3. Determine relationships between the psychological health of firefighters participating in the study and their allostatic load through application of analytical regression models.

3.2.1 Hypothesis

I hypothesize that the general physical health parameters taken from the study population will vary according to the psychological health responses measured. Therefore, I hope to observe a significant association between physiological health/well-being and allostatic load of these individuals.

3.3 Methodology

3.3.1 Study Population

We recruited six firefighters from the Waterloo Professional Firefighters Association IAFF local 791 in the city of Waterloo. An explanatory email concerning details of the study was sent to members of this association and the six participants voluntarily agreed to take part in the first phase of our study. The six participants fulfilled the eligibility criteria as they were all current active field firefighters, non-smokers, with no diagnosis of an acute stress disorder and without a history of a psychological and/or chronic illness. Participants were all Caucasian men. The average age of the participants was 39.5 years (standard deviation: 10.7), with ages ranging from 29-53 years. All the participants were born in Canada, with all, except one, having parents also born in Canada.

3.3.2 Procedure

We carried out the study procedure at the fire station nearest to the University of Waterloo. After each participant was briefed about the objectives of the project and procedure for collecting data, they were required to provide consent to move forward with data collection. After consent was granted, initial blood pressure measurements were collected, and participants completed self-report questionnaires before undergoing a brief interview regarding the questionnaires. Information pertaining to the effectiveness, relevance and possible changes to the questionnaire

were collected during this interview conducted by chief investigator. Anthropometric and physiologic data were then collected, which consisted of a meticulous process to ensure and control quality.

3.3.3 Instruments used for data collection

Each participant completed a set of 4 questionnaires (lasting a total of 20-25 minutes), which was administered in a standardized fashion across participants, as follows:

1) A demographic questionnaire: an in-house questionnaire that includes 6 questions relating to the demographic characteristics of participants; for example, the questionnaire collected information such as age, sex, ethnicity, place of birth, and primary language.

2) A general health questionnaire: an in-house questionnaire that includes 30 items relating to the lifestyle factors and medical history of the sample; for example, alcohol use, medication use, average amount of sleep, and the level of physical fitness. The general health questionnaire was modified from the Canadian Health Survey (CCHS), 2016 version.

3) A perceived stress questionnaire: a widely-used instrument with 10 questions that measure the degree to which situations in a person's life are believed to be stressful.

4) The Guarding Minds at Work survey (GM@W): a comprehensive, 68-item questionnaire that provides an index of performance across 13 psychosocial factors.

3.3.3.1 Perceived Stress Scale

The Perceived Stress Scale (PSS-10) is a widely used psychological instrument for measuring the perception of stress. Items in the scale are designed to appraise one's perception of stress (i.e., how unpredictable, uncontrollable, and overloaded respondents view their lives). Furthermore, the design of the PSS makes the instrument easy to interpret and understand. The items are general in nature, thereby making them free of content specific to any subpopulation group, and easily used by community samples with at least a junior high school education (Cohen & Williamson, 1988).

The PSS has been proven to possess significant validity and reliability. Cohen and his colleagues showed correlations with PSS and the following: stress measures, health behavior measures, help seeking behavior, self-reported health and health service measures, and smoking status (Cohen et al., 1983). For reliability of the PSS, study by Cohen et al (1983) reported a Cronbach's α between 0.84-0.86 and a test-retest reliability of 0.85. However, it is important to note the temporal nature of the PSS predictability; that is, as levels of perceived stress are influenced by daily hassles, major events, and alterations in coping resources, the predictive validity of the PSS is presumed to fall after 2 months.

The PSS-10 is scored using a Likert scale from 0-4 to measure responses to all ten questions and then summated by reversing responses (e.g., 0=4, 1=3, 2=2, 3=1, 4=0) to the four positively stated items (items 4, 5, 7, and 8) and then finding the sum across all scale items. The PSS range of scores falls between 0-40. Scores ranging from 0-13 would be regarded as low stress, 14-26, moderate stress and 27-40, considered as high perceived stress. Firefighters were considered to have a notable degree of perceived stress if their scores crossed the threshold of low stress (>13). A copy of the survey is present in the appendix.

3.3.3.2 Guarding Minds at Work Survey (GM@WS)

The GM@W survey is a comprehensive, evidence based, unique 68-item questionnaire designed to thoroughly assess the psychological health and safety of employees within an organization. The survey was created to provide a standardized measurement of psychosocial stressors at different types of workplace across Canada, and was designed based on extensive research that covers data analysis of a national sample and reviews of best practices from within Canada and internationally, plus existing and emerging Canadian case law and legislation. The GM@W survey is a free resource developed by researchers for the Center for Applied Research in Mental Health and Addiction (CARMHA) at the health sciences faculty at Simon Fraser University, British Columbia (Samra et al., 2012).

The GM@W survey assesses 13 psychosocial factors and provides a result based on performance across the factors. The 13 psychosocial factors have been shown to be consonant with domains pointed out by extensive research as areas of core psychosocial risk. Also, the factors are closely related and can influence one another. Therefore, positive or negative changes in one factor can impact the other factors in a similar fashion. The 13 psychosocial factors include: psychological support, organizational structure, clear leadership and expectations, civility and respect, psychological competencies and requirements, growth and development, recognition and reward, involvement and influence, workload management, balance, psychological protection, and protection of physical safety. For our study, we modified the questionnaire by removing 3 questions we believed were not relevant to the sample population, leaving our questionnaire with 13 psychosocial categories and 65 questions in total. As a result, each category was assessed by recording responses to 5 questions. The answers to the questions may have ranged from 1-4, which

means that the score for each psychosocial category could have ranged from 5 to 20. We scored the responses to each psychosocial category as follows: serious concern= 5-9, significant concerns= 10-13, minimal concern= 14-16, and relative strength= 17-20. A copy of the survey is presented in the appendix.

3.3.3.3 Allostatic load measurement

The ALI was constructed using 4 variables from the "big 5" proposed by Mauss et al. (2015): diastolic blood pressure, HbA1c, low-density lipoprotein (LDL) and WHR. The decision to exclude heart rate variability was due to the requirement of a significant financial investment in specialized recording instrumentation. In addition to the noted parameters, the following physiological and anthropometric parameters were collected: hair cortisol levels, HDL and triglyceride level, systolic blood pressure, and BMI. Participants were advised to abstain from alcohol, heavy meals, and physical exercise the evening before the physiological parameters were taken.

Blood pressure was measured before and after completing the questionnaire and the short interview. Systolic and diastolic blood pressure was recorded with the participant in a relaxed seated position on the arm of choice using an OMRON 3 Series model upper arm blood pressure monitor. Height in centimeters was taken using a standard stadiometer with participants standing upright. Weight measurement was performed on a digital scale with participants wearing light clothes and no shoes. BMI (weight in kilograms/height in meters^2) was then recorded for each of the participant. To determine WHR, waist circumference (centimeters) was measured using a measuring tape horizontally along the smallest circumference between the ribs and iliac crest and

hip circumference (centimeters) taken at the point of maximal posterior protrusion of the gluteal region (buttocks).

Blood lipid profile and glycosylated hemoglobin (HbA1c) were collected with the aid of a finger prick blood draw. After participants washed their hands and used a hand sanitizer, a finger prick using a spring-loaded lancet and a pipette was used to draw blood from the thumbs of each participant. The CardioChek PA analyzer (PTS Diagnostic, Sunnyvale USA) was used to measure lipoprotein levels. The CardioChek PA analyzer (CCPA) employs a dry-chemical testing for measurement of HDL-C, LDL and TG in whole blood. Individual blood samples were placed on a test strip and inserted into the CardioChek PA analyzer for analysis. A membrane in the test strip takes out the red blood cells and analyzes the plasma lipids concentration through horizontal flow using different enzymatic methods (Ferreira et al., 2015). To detect HDL and LDL, HDL was separated from LDL and VLDL with the aid of phospotungstic acid and a magnesium salt layer above the membrane fractionation layer. Triglycerides were evaluated by a colorimetric enzymatic method using lipoprotein lipase, glycerol phosphate oxidase and peroxidase (Ferreira et al., 2015).

A separate portion of the blood sample was collected using a special sample dilution kit that contained a sampler (0.37 mL of buffered detergent solution with ferricyanide), blood collector, and a product insert. Diluted blood samples were then placed on a test strip and inserted into the A1CNow+ analyzer (Chek diagnostic) to measure HbA1c levels. Insertion of the test strip propels a migration of blue microparticles conjugated to anti-A1C antibodies along the reagent strips. The amount of A1C was quantified by the amount of blue microparticles captured on the strips. Total hemoglobin (Hb) was also measured as the diluent converts Hb to met-Hb. The test results were then expressed as %A1C (A1C/ total Hb x 100).

To determine level of stress, we recorded cortisol levels from scalp hair of each participant. Cortisol, a steroid hormone, is produced in the body in response to stress, and is regulated by the hypothalamic-pituitary-adrenal axis (HPA; Wright et al., 2015). Hair cortisol overcomes limitations like the pulsatile circadian and ultradian nature of glucocorticoid secretion and the need to measure cortisol (HPA activity) at varying time intervals, often encountered when measuring cortisol from saliva, urine and blood (Ullmann et al., 2016). Scalp (hair) cortisol carries the advantage as a strong biomarker of chronic stress, which is essential since the focus of this study is on long term embedding of stressful experiences, rather than on acute stress measurement as observed in other methods of measurement (saliva, urine and blood) (Gow et al., 2010; Wright et al., 2015). In addition, the procedure is simple and non-invasive, while the samples themselves do not require special storage conditions. Sterile scissors were used to take a little sample (about 10 g) taken from their scalp hair, with a focus on approximately the first 3 cm of the hair shaft (given that hair grows at an average rate of 1cm/month, the sample should provide information on cortisol levels during the preceding 3 months). The hair samples were then sealed in envelopes and sent to a laboratory at the Department of Medicine, Western University for further processing.

On reaching the laboratory, the hair sample was weighed and then chopped into small pieces. The cut pieces were inserted into a scintillation vial with 1 mL of methanol added, which was sealed and incubated overnight at 52^{o}C. When incubation was done, the supernatant (methanol extract) was removed and transferred into disposable glass tubes. The solvent was extracted from each sample by evaporation in a dry bath (Thermolyne® Dri-Bath) under a stream of nitrogen gas (Techne® Sample Concentrator). On evaporation of methanol, the sample was re-suspended in 150-250 µL of phosphate-buffered saline solution at pH 8.0 and vortexed until well mixed. For

analysis, the cortisol in the hair samples was quantified using the Salivary ELISA Cortisol Kit © (Alpco Diagnostics ®, Windham, NH) (Sauve et al., 2007)

The ALI was calculated using the measured allostatic load parameters (cortisol, systolic and diastolic blood pressure, BMI, WHR, HbA1c, TC/HDL, and LDL; table 2) based on an AL formulation suited for clinical practice where the predefined cut off values are based on population norms. After all the parameters were collected, participants' values were then coded according to clinical reference ranges and combined into an ALI as follows: quartiles were calculated and participant values that fell within the highest 75^{th} percentile were scored as "1" while those that fell below the 75^{th} percentile were scored as "0" which was aggregated to yield an ALI for the biomarkers. Values for HDL-cholesterol were the only exception to this formulation, as values within the lowest 25^{th} percentile were scored as "1" (Juster et al., 2011). The sum score ranged from 0-9, with higher scores signifying higher allostatic load. Table 2 provides a summary of biomarkers used.

3.3.3.4 Statistical analysis

All data were entered into a computer spreadsheet using Excel for Windows 10 and categorical data analysis performed using R studio (version 1.0.136 – © 2009-2016 RStudio, Inc). Standard methods were utilized to calculate descriptive statistics, and, in addition to the means, standard deviations and ranges were calculated to represent the results. Interrelationships between single ALI parameters, age and both psychosocial questionnaires were investigated using Pearson correlations, while the relationship between the participants' PSS and GM@W score was measured using analysis of variance (ANOVA). We tested the differences in ALI related to low

and high psychosocial stress as observed in PSS and GM@W via the Wilcoxon- Mann-Whitney test. Regression analysis tested the relationship between the AL score (dependent variable) and both questionnaire scores (GM@W and PSS) as the independent variables. Model 1 tested the relationship between ALI and all the individual 13 psychosocial factors of the GM@W scale. Model 2 tested for a relationship between ALI and questionnaire scores (GM@W, PSS) after taking age into account. Summary of the regression models used can be found on page 110.

3.4 Ethical considerations

3.4.1 Approvals

Ethical approval was received from Office of Research Ethics (ORE) of the University of Waterloo before collection of data.

3.4.2 Information Sheet for the participants

In addition to the information session provided by the researcher, potential participants were provided with an information sheet that provided a detailed description of the study and requirements for participation. Contact information of the researcher was also included on the sheet. Willing participants were required to sign a consent form prior to data collection. A copy of the consent form can be found in the appendix.

3.4.3 Participant confidentiality and data storage

Participants were assured of data confidentiality and proper storage. All the participants were identified by numeric code. No personal information (e.g., names, phone number, or home address) was collected. Results from questionnaire were retrieved in Excel and hard copies destroyed. After analysis of hair samples, they were destroyed by University of Western approved destruction of

human tissue. Study data will be retained for a period of seven years as per University of Waterloo records and management policy.

3.5 Results

3.5.1 Study sample

The six participants recruited for the study responded to the questionnaires and took part in the measurement and analysis of physiological parameters. The participants were all active duty firefighters and white. None of the participants smoked, but all the firefighters reported varying levels of alcohol intake; 50% had more than one drink a week, 16.7% once a week and 33.3% had drinks once or twice a month. Table 3 summarizes the baseline demographics of the participating firefighters.

3.5.2 Questionnaire results

Concerning the questionnaires measuring perceived psychosocial stress, majority of the participants in this pilot study were stressed. Four participants showed considerable levels of stress (33.3% stressed, 33.3% highly stressed) on the PSS. Table 4 shows responses for the PSS. For the GM@W, two participants met the criteria for serious concern (highly stressed), while the rest fell in the category of minimal concern for stress. With regards to the 13 individual psychosocial categories in the GM@W scale, all participants response to 4 of the 13 categories fell within

"significant concern". These categories and their means include: Organizational structure (11.33), clear leadership and expectation (11.17), involvement and influence (13.17), and workload management (13.50). Table 5 shows the responses for the GM@W. The two psychosocial stress questionnaires (PSS and GM@W) showed strong intercorrelations and a significant association between them ($r=0.79$, $P \leq 0.05$). However, no intercorrelation was observed between PSS or GM@W and age.

3.5.3 Allostatic load results

Table 6 presents the distribution of all the AL parameters, their means and respective cut-off values that was used to calculate the ALI. The ALI score ranged from 0-9. The mean and standard deviation of the ALI comprising of all 9 variables were 4.17 and 1.72 respectively. We observed high means of the body mass index (27.65 kg/m^2) and systolic blood pressure (134.00 mmHg) that crossed their respective clinical thresholds. Table 6 presents the intercorrelation between single AL parameters and their relation to age, PSS and GM@W scales. We observed a significant association between certain AL parameters, between an AL parameter and PSS and one between an AL parameter and age. We found positive correlations and significant associations for BMI and diastolic blood pressure (r 0.9, $p = 0.005$), WHR and age (r 0.95, $p = 0.004$) and hair cortisol and PSS (r 0.87, $p = 0.02$). Strong positive correlation was observed for systolic blood pressure (r 0.66) and HbA1c (r 0.66) with PSS.

Regarding differences between high vs low scoring on the PSS and its association with AL average score, no statistical difference ($p > 0.05$) emerged between participants scoring high ($n = 4$) vs low ($n = 2$) on the PSS. Similar results were observed with the GM@W and corresponding

AL average score as no significant difference ($p > 0.05$) was observed between subjects reporting high stress on the GM@W ($n = 2$) versus individuals with low stress ($n = 4$). Regarding the 13 psychosocial factors of the GM@W scale and ALI, we found no statistical significant association between any of the individual psychosocial factors and ALI.

3.6 Discussion

In previous literature, research regarding work-related stress and its relation to unfavourable health outcomes within the fire-service has largely focused on individual biomarkers, or groups of risk factors. The application of the ALI, a score-based summary measure employed in this study, provides a significant and reliable approach to appraising the effect of work-related stress within firefighters.

The pilot study was conducted to investigate the existence of associations between adverse psychosocial work conditions and a cumulative measure of AL in 6 male firefighters. In doing so, we appraised psychological health using two validated questionnaires (PSS and GM@W) in 6 male firefighters. We also measured physiological biomarkers of the participating firefighters to calculate the ALI. We presumed that firefighters would exhibit high stress levels and report a positive association with a high ALI.

Altogether, our findings showed relatively high perceived stress levels among the participating firefighters. Psychosocial factors like organizational structure, clear leadership and expectation,

involvement and influence, and workload management raised the most concern among the participants. Similar findings were observed in a cohort of Korean firefighters who experienced high stress levels due to exposure to these psychosocial stressors (Ha et al., 2008). Notably, unfavourable health outcomes, from burnout to somatic diseases, have been linked to psychosocial stress (An et al., 2015; Choi et al., 2016; Jang et al., 2017).

Contrary to our hypothesis, we found no significant association between ALI and work-related stress among the participating firefighters in our study. No statistical difference emerged between the average allostatic load and participants with high versus low job strain/perceived stress. However, in contrast to our findings, prior studies performed on other occupational groups have documented existing relationship between AL and work-related stress. Studies performed on teachers (Bellingrath et al., 2009), industrial workers (Sun et al.,2007), and air-craft industry workers (Schnorpfeil et al.,2003) all reported positive significant associations between various work-place/psychosocial stressors and ALI. Age also played a significant role on the associations observed in those studies. However, after taking age into account in our study, there was no significant change in the results. The young age of our study population (mean age 39.5) might also play a role in our null findings, as they may have been too young to show the cumulative effect of workplace stress on allostatic load.

It is relatively difficult to make comparisons and draw conclusion from our results and that of others due to major differences in the characteristics of our sample. First, a major difference was in the sample size. Our sample size was relatively small compared to other studies that have used larger sample sizes (ranging from 30-3,887 participants) (Mauss et al.,2015). It could be argued that the sample size used in our study was not effective enough to affect the significance of the

relationships between the measured variables. The effect size (Cohen's D) of our sample was quite small (0.25) (Cohen, 1998). Second, other sample characteristics, such as gender, years in service, position, and socioeconomic factors, might have affected our results. Considering gender, our study sample was made up of male firefighters who were presently in active duty. Other studies have investigated ALI and workplace stress in samples consisting of both men and women (Juster et al., 2013; Sun et al., 2007). The mixed studies have shown associations present with women, but absent in men. Firefighters often have relatively high SES, occupational status and more control on life, increasing their likelihood of staying healthy and further affecting the investigated association.

Despite the inability to provide empirical support for our hypothesis, we found some noteworthy correlations with relative significance between parameters in the ALI, and between certain biomarkers and the PSS. Between biomarkers and PSS, we found a positive significant association between hair cortisol levels and perceived stress in our participants. A previous study employing hair cortisol analysis and measuring perceived stress via the PSS reported similar results, as higher hair cortisol levels were associated with higher perceived stress scores (Van Uum et al., 2008). A review paper investigating this association found identical results in three studies (Staufenbiel et al., 2013). Hair cortisol analysis measures long-term stress, so it's no surprise that participants who reported relatively high average on the PSS showed higher cortisol level. The correlation between the other parameters (systolic BP and HbA1c) and high PSS scores may share the same underlying mechanism (activation of the HPA axis) as the elevated cortisol levels associated with the PSS.

Elevation of blood pressure and HbA1c observed with high perceived stress levels can be explained by the direct activation of the neuroendocrine stress pathways (HPA and SAM) or

indirectly via individual health behavior (Janczura et al., 2015). This results in a stress-induced excessive sympathetic outflow and elevated cortisol production. Increased gluconeogenesis, lipolysis, cardiac output (elevation of heart rate and stroke volume), and constriction of the vasculature occur as an adaptive response. These changes may lead to insulin insensitivity/resistance, obesity and elevated blood pressure. With time, muscles responsible for vascular constriction, thicken, giving rise to elevated resting blood pressure and response stereotypy (Schneiderman et al., 2005; Chrousos, 2009).

Alcohol consumption within our study population was relatively high. Although we did not use a validated questionnaire to measure alcohol consumption levels, our methods and findings are similar to studies that have measured alcoholism among firefighters in some capacity (Hosoda et al., 2012; Vanderveen et al., 2012). Half of the participants in our study consumed more than one drink in a week. Increased alcohol use among firefighters may be linked to a need for a short-term coping tool, which often times results in drinking to cope (Bacharach et al., 2008).

3.6.1 Limitations

First, the study has the obvious limitation of a small sample size. Due to time limitations and the busy schedule of the firefighters in the Waterloo region, we could only recruit six firefighters. Nevertheless, the sample size was enough to conduct a pilot study. Second, the findings might have limited generalizability due the to recruitment of only male, active-duty firefighters from the Waterloo region alone; however, due to the presumed similarity of stress exposure within the firefighting community, we are confident that the data can be reasonably applied to other jurisdictions. Third, we might encounter some bias in the “healthy worker effect”. Firefighters are

known to face rigorous physical conditioning exercises and are generally fit, which might lead to an underestimation of the explored effects of work stress on their allostatic load measurement. Finally, the nature of this study (cross-sectional) leaves no room to draw any causal conclusions about the observed/investigated associations.

3.6.2 Conclusion

An important strength of this study lies in its novelty. The project is the “first of its kind" to measure the effect of work-related stress on allostatic load in firefighters. Our study found no significant association between allostatic load scores and workplace stress. High or low level of stress did not differ with regards to allostatic load index. Nevertheless, we found a positive association between an allostatic load parameter (hair cortisol level) and perceived stress scores. Despite the findings, this pilot study showed the relatively high workplace stress associated with firefighting. Further, the methods and techniques associated with the conduct of this study provides a framework for further studies in this field. It also adds to the growing work-related stress literature. Finally, understanding and addressing findings from this study contributes to the first-responders’ industry, as it provides a platform/template for creating better preventive protocol/regimen for its members.

CHAPTER FOUR

CONCLUSION AND IMPLICATION FOR RESEARCH AND PUBLIC HEALTH

4.1 Conclusion

Firefighters are usually at the forefront of emergency rescue and medical service provision, as well as conventional fire suppression. This workload coupled with psychosocial stress experienced at the workplace eventually takes its toll on their health. Research addressing this issue has largely focused on traumatic stressors and acute health outcomes in this population (Susan & Frederick, 2000; Shantz, 2002; Berger et al., 2012; Armstrong et al., 2014; Katsavouni et al., 2015; Stanley et al., 2016; Jahnke et al., 2016). However, psychosocial workplace stress has gained attention recently and has been proven to greatly affect short- and long-term health of firefighters. Therefore, I set out to investigate the nature and type of psychosocial stress experienced by firefighters by investigating work-related factors and its cumulative effects on their health by reviewing current literature. I also aimed to identify a range of physiological markers of chronic stress experience an allostatic load index) and determine relationships between allostatic load and work-related stress in a cohort of firefighters.

Results from the systematic review showed the significant role psychosocial stressors played on the health outcomes of the studied firefighters. Psychosocial factors including low social support,

job demand/pressure, lack of reward, poor organizational system, unfavourable occupational climate/environment, shift work and low rank of work and self esteem showed various associations with unfavourable health outcomes in firefighters.

The pilot study revealed moderate perceived stress levels amongst the sample population. The mean PSS for our sample was 17.67 (SD = 5.61). When compared to a male community sample from Cohen et al., 1983 (mean = 25.0, SD = 7.8), our mean was relatively low. However, in comparison with a study investigating perceived stress in a cohort of Korean firefighters (mean = 12.54, SD = 6.20; Lee et al., 2014), stress levels in our study were noticeably higher. When compared to other first responders, e.g., nurses (mean = 19.14, SD = 5.45; Lee et al., 2013) and policewomen (mean = 15.2, SD = 5.6; Wang et al., 2011), the results were quite similar as they all fell within the "moderate stress" range. According to our findings, significant associations were observed between hair cortisol level (stress response) and perceived stress reported by the firefighters. Systolic blood pressure and HbA1c showed positive correlation with perceived stress.

The study population reported certain psychosocial factors that called for significant concern, including organizational structure, clear leadership and expectations, involvement and influence, and workload management. Comparing the results of this study to the original GM@W nation-wide survey (Gilbert et al., 2012), we observed that poor organizational structure was a bigger problem among our sample (mean = 11.3) than the nation-wide study sample (mean = 15.7). Similar findings were observed with "involvement and influence", as our sample recorded a lower average (mean = 13.2) versus the national sample (mean = 18.0). Comparing the other two factors, they both reported a better average than the national sample average; clear leadership and expectation (11.2 vs 6.0) and workload management (13.5 vs 12.8).

The allostatic load index in our study population was relatively high when compared with other population groups (Mauss et al., 2015). Certain biomarkers of the ALI surpassed their cut-off levels (systolic blood pressure, BMI and hair cortisol levels). Despite high workplace stress levels and corresponding ALI, we were unable to find a significant association between ALI and workplace stressors in our study population.

The importance of this study lies in its novelty. Identifying these psychosocial factors provides a theoretical framework to build on for further research into this field. It also provides a framework for providing prevention strategies to eliminate or reduce the appearance of these psychosocial factors in the workforce. With knowledge of psychosocial factors affecting firefighters, advanced training and reorientation can be geared towards providing the necessary support and coping skills in dealing with psychosocial stressors.

Findings from the pilot study are also equally important. The inability to find a statistical association between ALI and workplace stressors might be due to the small sample size and other factors like "healthy worker effect" and the young age of the participants. However, this pilot study has provided an opportunity to address these technicalities associated with the methodology of such an important study. This knowledge will provide a better approach towards a more comprehensive study that will employ a large and effective sample size to arrive at clearer conclusions regarding stress and its association with allostatic load in firefighters.

In addition, with knowledge of the specific psychosocial factors affecting firefighters and long-term effect on their health, administrative policies should be made to mitigate these factors. For the local Waterloo fire-service, the underlying problem behind the psychosocial stress affecting

the firefighters was a leadership one. There seemed to be an ineffective leadership and organizational structure that catered to the needs of the firefighters, which was an interesting finding that coincided with results from the systematic review. Certain psychosocial stressors found in the systematic review (poor organizational system/structure and high job demands/workload management) raised significant concern amongst the participants in the pilot study. With these observations, a conclusion could be drawn stating that concern about issues of leadership and organizational structure might not be specific to Waterloo firefighters, but to firefighters in general.

Therefore, addressing the root problem of leadership and organizational structure will provide the most benefit. To achieve this, effective policies addressing organizational structure, clear and positive leadership, and job demand-reward imbalance should be considered as a goal. In addition, more funding directed towards providing effective coping strategies and support programs will help reduce psychological and psychosocial burden on firefighters and enhance wellbeing. Social programs and outreach events that provide social support should be encouraged. The culture of mental health shaming and stigmatization should also be addressed as it would positively enhance communication and reduce isolation and interpersonal conflict. Enhanced wellbeing of firefighters will translate into a healthier population and reduced economic burden on taxpayers.

Considerations for future research includes a form of longitudinal study to assess the effect of psychosocial stressors over time and determine a causal relationship. Also, factors such as gender, marriage status, rank of work, and years of service should be investigated in order to appraise any possible mediating or confounding effect.

References

An, S., Chung, Y. K., Kim, B. H., Kwak, K. M., Son, J., Koo, J., … Kwon, Y. (2015). The effect of organisational system on self-rated depression in a panel of male municipal firefighters. *Annals of Occupational and Environmental Medicine*, *27*, 1–7.

Ângelo, R. P., & Chambel, M. J. (2013). The Reciprocal Relationship Between Work Characteristics and Employee Burnout and Engagement : A Longitudinal Study of Fire fighters. *Stress Health*, *114*, 106–114.

Armstrong, D., Shakespeare-Finch, J., & Shochet, I. (2014). Predicting post-traumatic growth and post-traumatic stress in firefighters. *Australian Journal of Psychology*, *66*(1), 38–46.

Bacharach, S. B., Bamberger, P. A., & Doveh, E. (2008). Firefighters, critical incidents, and drinking to cope: The adequacy of unit-level performance resources as a source of vulnerability and protection. *Journal of Applied Psychology*, *93*(1), 155–169.

Barger, L. K., Rajaratnam, S. M. W., Wang, W., O'Brien, C. S., Sullivan, J. P., Qadri, S., … Czeisler, C. A. (2015). Common sleep disorders increase risk of motor vehicle crashes and adverse health outcomes in firefighters. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, *11*(3), 233–40.

Barros, V. V. De, Martins, L. F., Saitz, R., & Bastos, R. R. (2012). Mental health conditions , individual and job characteristics and sleep disturbances among firefighters. *Journal of Health Psychology*, *18*(3), 350–358.

Beaton, R., Murphy, S., Johnson, C., Pike, K., & Corneil, W. (1998). Exposure to duty-related incident stressors in urban firefighters and paramedics. *Journal of Traumatic Stress*, *11*(4), 821–8.

Beaton, R., Murphy, S., Pike, K., & Corneil, W. (1997). Social Support and Network Conflict in Firefighters and Paramedics. *Western Journal of Nursing Research*, *19*(3), 297–313.

Beaton, R., Murphy, S. (1993). Sources of occupational stress among firefighter/EMTs and

firefighter/paramedics and correlations with job-related outcomes. *Prehosp Disaster Med.* 8(2):140-50.

Bellingrath, S., Weigl, T., & Kudielka, B. M. (2009). Chronic work stress and exhaustion is associated with higher allostastic load in female school teachers. *Stress*, *12*(1), 37–48.

Berger, W., Figueira, I., Sá, S. De, Janeiro, R. De, Marques-portella, C., Sá, S. De, … Janeiro, R. De. (2012). Rescuers at risk: a systematic review and meta-regression analysis of the worldwide current prevalence and correlates of PTSD in rescue workers. *Soc Psychiatry Psychiatr Epidemiol*, *47*(6), 1001–1011.

Bongers, P. M., Ijmker, S., Van Den Heuvel, S., & Blatter, B. M. (2006). Epidemiology of work related neck and upper limb problems: Psychosocial and personal risk factors (Part I) and effective interventions from a bio behavioural perspective (Part II). *Journal of Occupational Rehabilitation*, *16*(3), 279–302.

Bornstein, M.H., Manian, N. (2013) Maternal Responsiveness and Sensitivity Re-Considered: Some Is More. *Development and Psychopathology* 25(4pt1):957-971

Brummett, B. H., Barefoot, J. C., Vitaliano, P. P., & Siegler, I. C. (2003). Associations among social support, income, and symptoms of depression in an educated sample: the UNC Alumni Heart Study. *International Journal of Behavioral Medicine*, *10*(3), 239–50.

Caldwell, J. C. (2001). Population health in transition. *Bulletin of the World Health Organization*, *79*(2), 159–160.

Carpenter, G. S. J., Carpenter, T. P., Kimbrel, N. A., Flynn, E. J., Pennington, M. L., Cammarata, C., … Gulliver, S. B. (2015). social support, stress, and suicidal Ideation in Professional Firefighters. *Am J Health Behav*, *39*(2), 191–196.

Career Cast, 2017. Most stressful jobs of 2017. Retrieved from www.careercast.com/jobs-rated/most-stressful-jobs-2017

Chandola, T., Brunner, E., & Marmot, M. (2006). Chronic stress at work and the metabolic syndrome: prospective study. *BMJ*, *80*(January), 1–5.

Chen, E., & Miller, G. E. (2007). Stress and Inflammation in excerbation of Asthma. *Brain Behav Immun.*, *21*(8), 993–999.

Choi, B., Schnall, P., & Dobson, M. (2016). Twenty - four - hour work shifts , increased job demands , and elevated blood pressure in professional firefighters. *International Archives of Occupational and Environmental Health*, *89*(7), 1111–1125.

Chrousos, G. (2009). Stress and disorders of the stress system. *Nature Reviews Endocrinology*, *5*(7), 374–381.

Chrousos, G., & Gold, P. (1992). The Concepts of Stress and Stress System Disorders Overview of physical and Behavioral Homeostasis. *JAMA: The Journal of the American Medical Association*,

267(9), 1244–1252.

Cohen, S., Janicki-Deverts, D., Doyle, W. J., Miller, G. E., Frank, E., Rabin, B. S., & Turner, R. B. (2012). Chronic stress, glucocorticoid receptor resistance, inflammation, and disease risk. *Proceedings of the National Academy of Sciences*, *109*(16), 5995–5999.

Cohen, S., Janicki-Deverts, D., & Miller, E. (2007). Psychological stress and disease. *JAMA: The Journal of the American Medical Association*, *298*(14), 1685.

Cohen, S., & Williamson, G. (1988). Perceived stress in a probability sample of the U.S. In S. Spacapam & S. Oskamp (Eds.), *The social psychology of health: Claremont Symposium on Applied Social Psychology* (pp. 31-67)

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. Journal of Health and Social Behavior, 24, 385-396.

Cohen, J. (1988) Statistical power analysis for the behavioral sciences (2nd ed.*)* (Hillsdale, NJ: Erlbaum)

Crompton, S. (2011). Main sources of stress among workers. *Component of Statistics Canada Catalogue*, (11), 44–51.

Damrongsak, M., Prapanjaroensin, A., & Brown, K. C. (2017). Predictors of Back Pain in Firefighters. *Workplace Health and Safety*, *20*(10), 1–9.

Danielsson, M., Heimerson, I., Lundberg, U., Stefansson, C., & Åkerstedt, T. (2012). Psychosocial stress and health problems Health in Sweden : The National Public Health Report 2012 . Chapter 6 ., *40*(Suppl 9), 121–134.

de Castro, A., Voss, J., Ruppin, A., Dominguez, C., & Seixas, N. (2010). Stressors Among Latino Day Laborers A Pilot Study Examining Allostatic Load. *American Association of Occupational Health Nurses Journal*, *58*(5), 185–196.

Evans, G. W., Kim, P., Ting, A. H., Tesher, H. B., & Shannis, D. (2007). Cumulative Risk , Maternal Responsiveness , and Allostatic Load Among Young Adolescents. *Development Psychology*, *43*(2), 341–351.

Ferreira, C. E. dos S., Franca, C. N., Correr, C., Zucker, M. L., Andriolo, A., & Scartezini, M. (2015). Clinical correlation between a point-of-care testing system and laboratory automation for lipid profile. *Clinica Chimica Acta*, *446*, 263–266.

Fisher, P., & Abrahamson, K (2001). The road back to wellness: Stress, burnout & trauma in law enforcement Victoria: Spectrum Press.

Fisher, P. & Abrahamson, K (2002) The managers guide to stress, burnout and trauma in human, emergency and health services

Fisher, P., & Etches, B. (2003). A Comprehensive Approach to Workplace Stress & Trauma in Fire-Fighting. *International Association of Firefighters 17th Redmond Symposium*, 1–7. Retrieved from

http://www.fisherandassociates.org/pdf/Firefighters_03.pdf

Ganster, D. C., & Rosen, C. C. (2013). *Work Stress and Employee Health: A Multidisciplinary Review*. *Journal of Management* (Vol. 39).

Gersten, O. (2009). Neuroendocrine biomarkers, social relations, and the costs of cumulative stress in Taiwan. *Social Sci Med*, *66*(3), 507–535.

Gilbert, M., Bilsker, D., Samra, J., & Shain., M. (2012). Sample GM@W Overview report. Centre for Applied. Research in Mental Health and Addiction (CARMHA).

Goldstein, D. S., & Mcewen, B. (2002). Allostasis , Homeostats , and the Nature of Stress. *Stress*, *5*(1), 55–58.

Gow, R., Thomson, S., Rieder, M., Uum, S. Van, & Koren, G. (2010). An assessment of cortisol analysis in hair and its clinical applications. *Forensic Science International*, *196*, 32–37.

Griep, R. H., Nobre, A. A., Guimarães, M., Alves, D. M., Jesus, M. De, Cardoso, L. D. O., … Chor, D. (2015). Job strain and unhealthy lifestyle : results from the baseline cohort study , Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). *BMC Public Health*, 1–10.

Griffin, M. A., & Clarke, S. (2011). Stress and well-being at work. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology*, vol. 3: 359-397.

Guglielmi, R. S., & Tatrow, K. (1998). Occupational Stress , Burnout , and Health in Teachers : A Methodological and Theoretical Analysis. *Review of Educational Research*, *68*(1), 61–99.

Ha, JH, Kim DI, Seo BS, Kim WS, Yoo SH, Kim SK (2008). Job stress and psychosocial stress among firefighters. *Korean J Occup Environ Med*, 20:104-111.

Haddock, C. K., Jahnke, S. A., Poston, W. S. C., Jitnarin, N., Kaipust, C. M., Tuley, B., & Hyder, M. L. (2012). Alcohol use among firefighters in the Central United States. *Occupational Medicine*, *62*, 661–664.

Hosoda, T., Osaki, Y., Okamoto, H., Wada, T., & Otani, S. (2012). Evaluation of Relationships among Occupational Stress , Alcohol Dependence and Other Factors in Male Personnel in a Japanese Local Fire Fighting Organization. *Yonago Acta Medica*, *55*, 63–68.

Jahnke, S. A., Carlos, W. S., Haddock, C. K., & Murphy, B. (2016). Firefighting and mental health : Experiences of repeated exposure to trauma. *Work*, *53*, 737–744.

Janczura, M., Bochenek, G., Nowobilski, R., Dropinski, J., Kotula-Horowitz, K., Laskowicz, B., … Domagala, T. (2015). The relationship of metabolic syndrome with stress, coronary heart disease and pulmonary function - An occupational cohort-based study. *PLoS ONE*, *10*(8), 1–20.

Jang, S., Ryu, H., Choi, S., & Lee, S. (2016). gastroesophageal reflux disease (GERD) and their Korea Psychological factors influence the gastroesophageal reflux disease (GERD) and their effect on quality of life among firefighters in South Korea. *International Journal of Occupational and*

Environmental Health, *3525*(September 2017), 1–6.

Jang, S., Ryu, H., Choi, S., & Lee, S. (2017). Psychological Factors Influence the Irritable Bowel Syndrome and Their Effect on Quality of Life among Firefighters in South Korea. *Pschiatary Investig*, *14*(4), 434–440.

Johnson, E. O., Chrousos, G., & Gold, P. (1992). Mechanisms of stress : A dynamic overview of hormonal and behavioral homeostasis Mechanisms of Stress : A Dynamic Overview of Hormonal and Behavioral Homeostasis. *Neuroscience and Biobehavioral Reviews*, *16*, 115–130.

Juster, R.-P., Moskowitz, D. S., Lavoie, J., & D'Antono, B. (2013). Sex-specific interaction effects of age, occupational status, and workplace stress on psychiatric symptoms and allostatic load among healthy Montreal workers. *Stress*, *16*(6), 616–629.

Juster, R., Russell, J. J., Almeida, D., & Picard, M. (2016). Allostatic load and comorbidities : A mitochondrial , epigenetic , and evolutionary perspective. *Development and Psychopathology*, *28*(2016), 1117–1146.

Juster, R., Sindi, S., Marin, M., Perna, A., Hashemi, A., Pruessner, J. C., & Lupien, S. J. (2011). A clinical allostatic load index is associated with burnout symptoms and hypocortisolemic profiles in healthy workers. *Psychoneuroendocrinology*, *36*, 797–805.

Kang, S. (2015). The Korean Occupational Stress Scale questionnaire in English, *89*(5).

Katsavouni, F., Bebetsos, E., Malliou, P., & Beneka, A. (2015). The relationship between burnout , PTSD symptoms and injuries in firefighters. *Occupational Medicine*, *66*, 32–37.

Kim, M. G., Kim, K., Ryoo, J., & Yoo, S. (2013). Relationship between Occupational Stress and Work-related Musculoskeletal Disorders in Korean Male Firefighters. *Annals of Occupational and Environmental Medicine*, *25*(9), 1–7.

Kim, Y., Ahn, Y., Kim, K., Yoon, J., & Roh, J. (2016). Association between job stress and occupational injuries among Korean fi re fi ghters : a nationwide cross-sectional study. *British Medical Journal Open*, *6*, 1–9.

Kitlinska, J., & Tilan, J. (2010). Sympathetic neurotransmitters and tumor angiogenesislink between stress and cancer progression. *Journal of Oncology*, *2010*, 14–16.

Kivimäki, M., Virtanen, M., Elovainio, M., Kouvonen, A., Väänänen, A., & Vahtera, J. (2006). Work stress in the etiology of coronary heart disease—a meta-analysis. *Scandinavian Journal of Work, Environment & Health*, *32*(6), 431–442.

Koolhaas, J. M., Bartolomucci, A., Buwalda, B., Boer, S. F. De, Flügge, G., Korte, S. M., … Fuchs, E. (2011). Neuroscience and Biobehavioral Reviews Stress revisited : A critical evaluation of the stress concept. *Neuroscience and Biobehavioral Reviews*, *35*(5), 1291–1301.

Kulkarni, G. (2006). Burnout. *Indian Journal of Occupational and Environmental Medicine*. 10.1 (January-April 2006)

Langelaan, S., Bakker, A., Schaufeli, W., van Rhenen, W., & van Doornen, L. (2007). Is burnout related to allostatic load.pdf. *International Journal of Behavioral Medicine*, *14*(4), 213–221.

Larsson, G., Berglund, A. K., & Ohlsson, A. (2016). Daily hassles , their antecedents and outcomes among professional first responders : A systematic literature review. *Scandinavian Journal of Psychology.*, *57*, 359–367.

Lee, K., Suh, C., Kim, J., & Park, J. O. (2017). The impact of long working hours on psychosocial stress response among white-collar workers. *Indian Pediatrics*, *55*, 46–53.

Lee, J.S., Joo,E.J., Choi,K.S.(2013).Perceived stress and self-esteem mediate the effects of work-related stress on depression. *Stress Health* 29,75–81.

Lee, J., Ahn, Y., Jeong, K., Chae, J., & Choi, K. (2014). Resilience buffers the impact of traumatic events on the development of PTSD symptoms in firefighters. *Journal of Affective Disorders*, *162*(Complete), 128-133.

Lim, D., Baek, K., Chung, I., & Lee, M. (2014). Factors Related to Sleep Disorders among Male Firefighters. *Annals of Occupational and Environmental Medicine*, *26*(1), 1–8.

Lucassen, P., Oomen, C., Naninck, E., Fitzsimons, C., Van Dam, A.-M., Czeh, B., & Korosi, A. (2015). Regulation of Adult Neurogenesis and plasticity by (early) stress, glucocorticoids, and Inflammation. *Cold Spring Harb Perspect Biol*, *7*.

Maslach, C., & Jackson, S. E. (1996). Maslach Burnout Inventory—Human Services Survey (MBI–HSS) . In C. Maslach, S. E. Jackson, & M. P. Leiter (Eds.), MBI manual (3rd ed.). Palo Alto, CA : Consulting Psychologists Press

Mauss, D., Jarczok, M. N., Fischer, J. E., & Hum, S. (2016). The streamlined Allostatic Load Index: a replication of study results. *Stress*, *3890*(August).

Mauss, D., Jarczok, M. N., Fischer, J. E. (2015). A streamlined approach for assessing the Allostatic Load Index in industrial employees. *Stress* 18(4), 475-483

Mauss, D., Li, J., Schmidt, B., Angerer, P., & Jarczok, M. N. (2015). Measuring allostatic load in the workforce : a systematic review. *Industrial Health*, *53*, 5–20.

McEwen, B. S. (1998). Stress, Adaptation, and Disease. *Annals New York Academy of Science*, 33–44.

McEwen, B. S. (2000). The neurobiology of stress : from serendipity to clinical relevance 1. *Brain Research*, *886*, 172–189.

McEwen, B. S. (2000). Allostasis and Allostatic Load : Implications for Neuropsychopharmacology. *Neuropsychopharmacology* 99.

McEwen, B. S., & Wingfield, J. C. (2010). What is in a name? Integrating homeostasis, allostasis and

stress. *Hormones and Behavior*, *57*(2), 105–111.

McEwen, B.S., & Stellar, E. Stress and the individual. Mechanisms leading to disease. *Arch Intern Med*. 1993 Sep 27;153(18):2093-101

Merz, N. B., Dwyer, J., Nordstrom, C., Walton, K., Salerno, J. W., & Schneider, R. (2002). Psychosocial stress and cardiovascular disease: Pathophysiological links. *Behavioural Medicine*, *27*(4), 141–147.

Meyer, E. C., Zimering, R., Daly, E., Knight, J., Kamholz, B. W., & Gulliver, S. B. (2012). Predictors of Posttraumatic Stress Disorder and Other Psychological Symptoms in Trauma-Exposed Firefighters. *Psychological Services*, *9*(1), 1–15.

Mirolla, M. (2004). The cost of chronic disease in Canada. *The Chronic Disease Prevention Alliance of Canada*, 1-129

Mitani, S., Fujita, M., Nakata, K., & Shirakawa, T. (2006). Impact of post-traumatic Stress disorder and job-related stress and burnout: a study of fire service workers. *The Journal of Emergency Medicine*, *31*(1), 7–11

Mohd, R. S. (2008). life event, stress and illness. *Malaysian Journal of Medical Sciences*, *15*(4), 9–18.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7).

Niedhammer, I., Sultan-Taïeb, H., Chastang, J. F., Vermeylen, G., & Parent-Thirion, A. (2014). Fractions of cardiovascular diseases and mental disorders attributable to psychosocial work factors in 31 countries in Europe. *International Archives of Occupational and Environmental Health*, *87*(4), 403–411.

Ogi, N. (2016). Association between resiliency and posttraumatic growth in firefighters : the role of stress appraisal. *International Journal of Occupational Safety and Ergonomics*, *22*(1), 40–48.

Ontario Ministry of Health and Long-term care, O. (2007). *Preventing and Managing Chronic Disease : Ontario's Framework*.

Park, K., Wilson, M., & Lee, M. (2004). Effects of Social Support at Work on Depression and Organizational Productivitty. *Am J Health Behav.*, *28*(5), 444.455.

Peltzer, K., Shisana, O., Zuma, K., Wyk, B. Van, & Zungu-dirwayi, N. (2009). Job stress , job satisfaction and stress-related illnesses among South African educators. *Stress and Health*, *257*(December 2008), 247–257.

Plat, M. J., Frings-dresen, M. H. W., Sluiter, J. K., Frings-dresen, M. H. W., & Judith, K. (2016). Diminished health status in firefighters. *Ergonomics*, *139*(September), 2–6.

Public Health Agency of Canada. (2016). How healthy are Canadians? A trend analysis of the health of Canadians from a healthy living and chronic disease perspective. 2001 Annual report. *Stress and*

well-being. Health. https://doi.org/82-003-SPE

Quick, J. C., & Henderson, D. F. (2016). Occupational Stress : Preventing Suffering , Enhancing Wellbeing. *International Journal of Environmental Research and Public Health*, 1–11.

Regehr, C., Hill, J., Knott, T., & Sault, B. (2003). Social support , self-efficacy and trauma in new recruits and experienced firefighters. *Stress and Health*, *19*, 189–193.

Romero, L. M., Dickens, M. J., & Cyr, N. E. (2009). The reactive scope model - A new model integrating homeostasis, allostasis, and stress. *Hormones and Behavior*, *55*(3), 375–389.

Rosmond, R. (2005). Role of stress in the pathogenesis of the metabolic syndrome . *Psychoneuroendocrinology*, *30*, 1–10.

Rutters, F., Pilz, S., Koopman, A. D., Rauh, S. P., Te, S. J., Stehouwer, C. D., … Dekker, J. M. (2014). Social Science & Medicine The association between psychosocial stress and mortality is mediated by lifestyle and chronic diseases : The Hoorn Study. *Social Science & Medicine*, *118*, 166–172.

Ryan, R. (2013). Cochrane Consumers and Communication Review Group: data synthesis and and analysis, 1–5. Retrieved from http://cccrg.cochrane.org/author-resources

Saijo, Y., Ueno, T., & Hashimoto, Y. (2007). Job Stress and Depressive Symptoms Among Japanese Fire Fighters. *American Journal of Industrial Medicine*, *50*, 470–480.

Saijo, Y., Ueno, T., & Hashimoto, Y. (2008). Twenty-Four-Hour Shift Work , Depressive Symptoms , and Job Dissatisfaction Among Japanese Firefighters. *American Journal of Industrial Medicine*, *51*, 380–391.

Saijo, Y., Ueno, T., & Hashimoto, Y. (2012). Post-Traumatic Stress Disorder and Job Stress among Firefighters of Urban Japan. *Prehospital and Disaster Medicine*, *27*(1), 59–63.

Salvagioni, D. A. J., Melanda, F. N., Mesas, A. E., González, A. D., Gabani, F. L., & De Andrade, S. M. (2017). Physical, psychological and occupational consequences of job burnout: A systematic review of prospective studies. *PLoS ONE*, *12*(10), 1–29.

Samra, J., Gilbert, M., Shain, M., & Bilsker, D. (2012). What is Guarding Minds @ Work?, 1–2. Retrieved from https://www.guardingmindsatwork.ca

Schneiderman, N., Ironson, G., & Siegel, S. D. (2005). Stress and Health: Psychological, Behavioral, and Biological Determinants. *Annu Rev Clin Psychol*, *1*, 1–19.

Seeman, T. E., Mcewen, B. S., Rowe, J. W., & Singer, B. H. (2001). Allostatic load as a marker of cumulative biological risk : MacArthur studies of successful aging. *Proceedings of the National Academy of Sciences*, *98*(8).

Seeman, T. E., Singer, B. H., Rowe, J. W., Horwitz, R. I., & Mcewen, B. S. (1997). Price of Adaptation-Allostatic load and its Health consequences. *Arch Int Med*, 2259–2268.

Shantz, M. C. (2002). Effect of Work Related Stress On Firefighters/Paramedic Fire Staff and Command.

1-33.

Shin, J., Lee, J., Yang, S., Lee, M., & Chung, I. (2016). Factors related to heart rate variability among firefighters. *Annals of Occupational and Environmental Medicine*, 1–9.

Siegrist, J., & Rödel, A. (2006). Work stress and health risk behavior. *Scandinavian Journal of Work, Environment & Health*, *32*(6), 473–481.

Stansfeld S., & Candy B (2006). Psychosocial work environment and mental health—a meta-analytic review. *Scand J Work Environ Health* 32(6, special issue):443–462.

Staufenbiel, S. M., Penninx, B., Spijker, A. T., Elzinga, B. M., & van Rossum, E. F. C. (2013). Hair cortisol, stress exposure, and mental health in humans: A systematic review. *Psychoneuroendocrinology*, *38*(8), 1220–1235.

Steptoe, A. (2016). Stress resilience and risk of type 2 diabetes mellitus. *Nature Reviews Endocrinology*, *12*.

Steptoe, A., & Kivimäki, M. (2013). Stress and Cardiovascular Disease: An Update on Current Knowledge. *Annual Review of Public Health*, *34*(1), 337–354.

Sterling, P.,&Eyer, J. (1988). Allostasis:Anew paradigm to explain arousal pathology. In S. Fisher & J. Reason (Eds.), Handbook of life stress, cog- nition and health (pp. 629–649).

Sauve, B., Koren, G., Walsh, G., Tokmakejian, S., Van Uum, S.H.M. (2007). Measurement of cortisol in human hair as a biomarker of systemic exposure. *Clin Invest Med* 2007; 30 (5): E183-E191.

Sun, J., Wang, S., Zhang, J.-Q., & Li, W. (2007a). Assessing the cumulative effects of stress: The association between job stress and allostatic load in a large sample of Chinese employees. *Work & Stress*, *21*(4), 333–347.

Surwit, R. S., Schneider, M. S., & Feinglos, M. N. (1992). Stress and diabetes mellitus. *Diabetes Care*, *15*(10), 1413–1422.

Susan, M., & Frederick, A. (2000). Work-stress burnout in emergency medical technicians and the use of early recollections. *Journal of Employment Counseling*, *37*, 216–228.

Tak, S., Driscoll, R., Bernard, B., & West, C. (2007). Depressive Symptoms among Firefighters and Related Factors after the Response to Hurricane Katrina. *Journal of Urban Health*, *84*(2), 153–161.

Ullmann, E., Barthel, A., Petrowski, K., Stalder, T., Kirschbaum, C., & Bornstein, S. R. (2016). Pilot study of adrenal steroid hormones in hair as an indicator of chronic mental and physical stress. *Nature Publishing Group*, (April), 1–7.

Van Uum, S. H. M., Sauvé, B., Fraser, L. A., Morley-Forster, P., Paul, T. L., & Koren, G. (2008). Elevated content of cortisol in hair of patients with severe chronic pain: A novel biomarker for stress. *Stress*, *11*(6), 483–488.

Vanderveen, J. W., Gulliver, S. B., Morissette, S. B., Marc, K., Kamholz, B., Zimering, R., … Keane, T.

(2012). Differences in Drinking Patterns, Occupational Stress, and Exposure to Potentially Traumatic Events among Firefighters: Predictors of Smoking Relapse. *Am J Addict*, *21*(6), 550–554.

Vanitallie, T. B. (2002). Stress : A Risk Factor for Serious Illness, *51*(6), 40–45.

Visser, B., & Diee, J. H. Van. (2006). Pathophysiology of upper extremity muscle disorders. *Journal of Electromyography and Kinesiology*, *16*, 1–16.

Wang, Z., Chen, J., Boyd, J. E., Zhang, H., Jia, X., Qiu, J., . . . Xiao, Z. (2011). Psychometric properties of the chinese version of the perceived stress scale in policewomen. *PLoS ONE*, *6*(12).

Williams, S., & Cooper, G. L. (1998). Measuring Occupational Stress : Development of the Pressure Management Indicator. *Journal of Occupational Health Psychology*, *3*(4), 306–321.

Wright, K. D., Hickman, R., & Laudenslager, M. L. (2015). Hair Cortisol Analysis : A Promising Biomarker of HPA Activation in Older Adults, *55*, 140–145.

Yach, D., Hawkes, C., Gould, L. C., & Hofman, K. J. (2004). The Global Burden of Chronic Diseases Overcoming Impediments to Prevention and Control. *JAMA: The Journal of the American Medical Association*, *291*(21), 2616–2622.

APPENDIX A

Information Letter and Consent Form

Project Title: Does Occupational Stress Encountered by First Responders Increase Allostatic Load?

Investigators:

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You are invited to participate in a study assessing associations amongst life stress, occupational factors, and mental/physical health. The purpose of this study is to understand whether exposure to the sort of occupational stress unique to first responders has a negative impact on their health and well-being.

What You Will Be Asked to Do

You will be asked to complete 4 questionnaires that ask about your background (e.g., gender, ethnicity), various health-related conditions and behaviours (e.g., smoking, physical activity), your perceptions of general life stress during the last month, and your views about psychological health and safety in your workplace. Some of the questions in the questionnaires are sensitive in nature. You always have the option of choosing not to respond to any question, or to speak with an experimenter if you have concerns about a question.

As well, you will be asked to allow the measurement of basic physiological characteristics (e.g., blood pressure and body weight), and will be asked to provide a small sample of blood from a finger prick (to allow for the measurement of blood sugar and lipids) and to provide a small sample of hair (to allow for the measurement of stress hormones).

Please note that your answers to the questionnaires and your biomarkers will remain anonymous and confidential, and will only be used for the purposes of this research study.

Participation and Remuneration

This study should take approximately 40 minutes to complete. Participation is voluntary, and you may choose to discontinue the study at any time if you wish with no penalty. Also, you can withdraw your data from this study at any time up to the point of publication of the research by contacting the faculty investigators.

Personal Benefits of the Study

The benefits of participation in this study include learning about research in health psychology in general and the topic of this study in particular. You will receive additional background information about the study. There are no other personal benefits to participation.

Risks to Participation in the Study

Some of our questions may be viewed as sensitive in nature. For example, we ask participants to reflect upon their current level of stress, their physical and mental health concerns (e.g., diabetes and blood pressure), and their adoption of health-risk behaviours (e.g., cigarette and alcohol use).

Some participants may experience discomfort when reflecting upon these kinds of questions. Please keep in mind that you may speak with the experimenter about any question before you provide a response, you may choose not to respond to any question for whatever reason, you may withdraw your participation at any time without penalty, and you may speak with the faculty investigators if you have questions/concerns related to the study.

Confidentiality

Any data pertaining to you as an individual participant will be kept confidential. Paper-based data will be stored in a locked file cabinet in a locked office in the research laboratory of Dr. John G. Mielke. Electronic data will be stored in an encrypted format on a password protected computer. Data from this study will be retained indefinitely and may only be accessed by researchers involved in this study. When information is transmitted over the internet, privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers). University of Waterloo researchers will not collect or use internet protocol (IP) addresses or other information which could link your participation to your computer or electronic device without first informing you. If you prefer not to participate using this online method, please contact one of the researchers so you can participate using an alternative method such as a paper-based questionnaire. The alternate method may decrease anonymity, but confidentiality will be maintained.

Results of the study will be presented (e.g., conference presentations, papers) at the group level only. It will not be possible to determine any individual participant's data from the results nor will the results of any individual be shared.

Questions and Research Ethics Clearance

If after receiving this letter, you have any questions about this study, or would like additional information to assist you in reaching a decision about participation, please feel free to contact either of the faculty members listed at the top of this form.
This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. Participants who have questions for the committee about their involvement in the study may contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567, ext. 36005 or ore-ceo@uwaterloo.ca.

Thank you for your interest in our research and for your assistance with this project.

Consent of Participant

I have read the information presented in the information letter about a study being conducted by Drs. Bigelow and Mielke of the School of Public Health & Health Systems at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted. I am aware that I may withdraw from the study at any time by advising the researchers of this decision.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567, ext. 36005, or ore-ceo@uwaterloo.ca

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

_____

Print Name

_____

Signature of Participant

_____

Dated at Waterloo, Ontario

_____Witnessed

APPENDIX B

Feedback Letter

Project Title: Does Occupational Stress Encountered by First Responders Increase Allostatic Load?

Investigators:

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We would like to thank you for your participation in this study. As a reminder, the purpose of this study is to understand whether exposure to the sort of occupational stress unique to first responders has a negative impact on their health and well-being. We assessed occupational stress using self-report questionnaires, and the impact on health using the collected biomarkers. Your participation will help to further our understanding about the connection between occupational stress, psychological health and safety in the workplace, and health outcomes later in life.

Please remember that any data pertaining to you as an individual participant will be kept confidential. Once all the data are collected and analysed for this project, information will be shared with the research community through seminars, conferences, presentations, and journal articles. Data will be presented at the group level only and participants will not be identified individually in any way. Paper records of data collected during this study will be retained indefinitely in a locked filing cabinet in BMH 2101, to which only researchers associated with this study have access. Electronic data will be kept indefinitely on a secure computer in a locked room in BMH 2101, to which only researchers associated with this study have access. All identifying information will be removed from the records prior to storage.

If you are interested in receiving more information regarding the results of this study, or would like a summary of the results, please provide your email address to the experimenter, and we will send you this information when the study is completed (anticipated July, 2017). In the meantime, if you have any questions about the study, please do not hesitate to contact either of the faculty investigators by email or telephone as noted above.

As with all University of Waterloo projects involving human participants, this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#XXXXX). If you have questions for the Committee, pleased contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005, or ore-ceo@uwaterloo.ca.

For all other questions contact Dr. Somkene Igboanugo at sigboanugo@uwaterloo.ca

APPENDIX C

Background information of the participant

Demographic Questionnaire

Please provide the following information regarding your background.
All of the answers provided will remain confidential. However, if you do not feel comfortable answering a question, please leave the answer blank.

1. Age: _____

2. Gender: Female □ Male □ Other □

3. Which statement best describes you?

- you were born in Canada, but both of your parents were born elsewhere □
- you and one of your parents were born in Canada, but your other parent was born elsewhere □
- you and both of your parents were born in Canada, but all of your grandparents were born elsewhere □

4. What is your ethnic background? Please mark all that apply.

□ Aboriginal	□ Vietnamese		□ Hispanic
□ Black/African	□ Indian		□ Arab
□ Chinese (including Hong Kong Chinese and Taiwanese)	□ Pakistani		□ Persian
□ Japanese	□ Sri Lankan		□White/European
□ Korean	□ Caribbean		□ Other (list):

5. What is your primary language? _____

6. Have you been exposed to English since birth? Yes □ No □

If **NO**, at what age were you first exposed to English (in years): _____

General Health Questionnaire

Please provide the following information regarding your general health status and health-related behaviour. If you do not feel comfortable answering a question, please choose the **RF (refuse to answer)** option; if you are not sure about an answer, please choose the **DK (do not know)** option.

Section One

The following segment asks about "long-term conditions" (those expected to last, or have already lasted, at least 6 months) that have been diagnosed by a health professional.

1) Do you have asthma, chronic bronchitis, emphysema, or chronic obstructive pulmonary disease?

Yes _____ RF _____

No _____ DK _____

2) Do you have high blood pressure?

Yes _____ RF _____

No _____ DK _____

3) In the past month, have you taken any medicine for high blood pressure?

Yes _____ RF _____

No _____ DK _____

4) Do you have high blood cholesterol, or lipids?

Yes _____ RF _____

No _____ DK _____

5) In the past month, have you taken any medicine for high blood cholesterol, or lipids?

Yes _____ RF _____

No _____ DK _____

6) Do you have diabetes?

Yes _____ RF _____

No _____ DK _____

7) Do you currently take insulin for your diabetes?

Yes _____ RF _____

Not applicable _____ DK _____

8) In the past month, did you take pills to control your blood sugar?

Yes _____ RF _____

No _____ DK _____

9) Do you have a mood disorder such as depression, bipolar disorder, mania, or dysthymia?

Yes _____ RF _____

No _____ DK _____

10) Do you have an anxiety disorder such as obsessive-compulsive disorder, post-traumatic stress syndrome, or a panic disorder?

Yes _____ RF _____

No _____ DK _____

Section Two

The following segment asks about the nature of your sleeping habits.

1) How long do you usually spend sleeping each night?

fewer than 4 hours	_____	RF	_____
4 hours to less than 6 hours	_____	DK	_____
6 hours to less than 8 hours	_____		
more than 8 hours	_____		

2) How often do you have trouble going to sleep, or staying asleep?

Never	_____	RF	_____
Rarely	_____	DK	_____
Sometimes	_____		
Most of the time	_____		
All of the time	_____		

3) How often do you find your sleep refreshing?

Never	_____	RF	_____
Rarely	_____	DK	_____
Sometimes	_____		
Most of the time	_____		
All of the time	_____		

Section Three

The next segment asks about cigarette smoking.

1) Presently, do you smoke cigarettes every day, occasionally, or not at all?

Daily _____

Occasionally _____

Not at all _____

RF _____

2) In the past 30 days, did you smoke any cigarettes?

Yes _____ RF _____

No _____ DK _____

3) How many cigarettes do you tend to smoke on a typical day?

_____

4) In the past 30 days, did you smoke any cigars, cigarillos (little cigars), a pipe, or make use of a hookah?

Yes _____ RF _____

No _____ DK _____

5) In the past 30 days, did you use an electronic cigarette, also known as an "e-cigarette"?

Yes _____ RF _____

No _____ DK _____

Section Four

The following set of questions asks about your alcohol consumption.

A "drink" refers to:
- a bottle, or small can of beer, cider or cooler with 5% alcohol content
- a small draft
- a glass of wine with 12% alcohol content
- a glass or cocktail containing 1 oz. of a spirit with 40% alcohol content

1) Have you ever had a drink in your lifetime?

Yes _____ RF _____

No _____ DK _____

2) During the past 12 months, how often did you drink alcoholic beverages?

Not at all _____

Less than once a month _____

Once a month _____

2 to 3 times a month _____

Once a week _____

2 to 3 times a week _____

4 to 6 times a week _____

Every day _____

RF _____

DK _____

Section Five

The next series of questions are about various medications.

The first series of questions is about your use of various pain relievers. By pain relievers, we mean products that contain opioids, such as codeine. Most of these products require a prescription, although some codeine products are available without a prescription (for example, Tylenol #1).

We are not interested in pain relievers such as Aspirin, Advil, or regular Tylenol.

1) During the past 12 months, have you used any pain relievers? (including codeine products, like Tylenol #3, 292s or 222s; oxycodone products, such as Percocet, or Percodan; other opioid products, such as Dilaudid or Demerol)

Yes _____ RF _____

No _____ DK _____

2) If so, how often during the past 12 months did you use any such pain relievers?

not applicable _____

once, or twice _____

3 to 11 times a year _____

about once a month _____

2 or 3 times a month _____

about once, or twice a week _____

3 or 4 times a week _____

daily, or almost daily _____

as needed, or following surgery _____

RF _____

DK _____

The next few questions are about the use of various stimulants.

By stimulants, we mean products prescribed by a doctor to help people who have attention, or concentration problems (such as ADHD). Examples of stimulants include Ritalin, Concerta, Adderall, and Dexedrine.

1) During the past 12 months, have you used any stimulants?

Yes _____	RF _____
No _____	DK _____

2) If so, how often during the past 12 months did you use any stimulants?

not applicable	_____
once, or twice	_____
3 to 11 times a year	_____
about once a month	_____
2 or 3 times a month	_____
about once, or twice a week	_____
3 or 4 times a week	_____
daily, or almost daily	_____
as needed	_____
RF	_____
DK	_____

The next few questions are about your use of various sedatives, or anti-anxiety medications.

By sedatives, we mean products that can be obtained from a doctor, such as diazepam, Valium, lorazepam, Ativan, alprazolam, Xanax, clonazepam, Rivotril.

Sedatives are sometimes prescribed to help people sleep, calm down, or to relax their muscles.

1) During the past 12 months, have you used any sedatives?

Yes _____ RF _____

No _____ DK _____

2) If so, how often during the past 12 months did you use any sedatives?

not applicable _____

once, or twice _____

3 to 11 times a year _____

about once a month _____

2 or 3 times a month _____

about once, or twice a week _____

3 or 4 times a week _____

daily, or almost daily _____

as needed _____

RF _____

DK _____

Section Six

The following questions ask about various types of physical activities done in the last 7 days. Please consider only those activities that you did for a minimum of 10 continuous minutes.

1) In the last 7 days, did you use active ways like walking, or cycling to get to places such as work, or a shopping Centre?

Yes _____ RF _____

No _____ DK _____

2) Not including the activities reported above, in the last 7 days, did you do sports, fitness, or recreational physical activities (organised, or non-organised), that lasted a minimum of 10 continuous minutes? Examples are walking, home or gym exercise, swimming, cycling, running, and all team sports.

Yes _____ RF _____

No _____ DK _____

3) In the last 7 days, did you do any other physical activities while at work, in or around your home, or while volunteering? Examples are carrying heavy loads, shoveling, and household chores such as washing windows. Please remember to only include activities that lasted a minimum of 10 continuous minutes.

Yes _____ RF _____

No _____ DK _____

Perceived Stress Scale

Please answer the following questions about your thoughts and feelings **during the last month**. In each case, you will be asked to indicate by circling *how often* you felt, or thought a certain way.

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1) In the last month, how often have you been upset because of something that happened unexpectedly?

0 1 2 3 4

2) In the last month, how often have you felt that you were unable to control the important things in your life?

0 1 2 3 4

3) In the last month, how often have you felt nervous and "stressed"?

0 1 2 3 4

4) In the last month, how often have you felt confident about your ability to handle personal problems?

0 1 2 3 4

5) In the last month, how often have you felt that things were going your way?

0 1 2 3 4

6) In the last month, how often have you found that you could not cope with all the things that you had to do?

0 1 2 3 4

7) In the last month, how often have you been able to control irritations in your life?

0 1 2 3 4

8) In the last month, how often have you felt that you were on top of things?

0 1 2 3 4

9) In the last month, how often have you been angered because of things that were outside of your control?

0 1 2 3 4

10) In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

0 1 2 3 4

GM@W Survey

What is GM@W?

Guarding Minds @ Work (GM@W) is a unique, evidence-based, comprehensive set of resources designed to effectively assess and address psychological health and safety in the workplace. A psychologically healthy and safe workplace is one that promotes employees' psychological well-being and actively works to prevent harm to employee psychological health due to negligent, reckless or intentional acts.

You are being asked to complete this survey because your workplace is undertaking a review of its psychological health and safety. Employee input is a critical component of this review.

Survey Instructions: This survey contains 65 statements about common work experiences. The statements cover a range of topics including work responsibilities, work relationships, and leadership.

Please indicate whether you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with each statement.

When responding to these statements, please keep the following in mind:

- Answer based on your own personal experiences in your current job.
- Choose the answer that is true most of the time.
- This survey is concerned with your thoughts, opinions and feelings. If you are unsure of an answer, please select the option that you believe is most likely to be true.
- These statements use the terms 'employee', 'staff', 'supervisor', 'management' and 'employer', however your workplace may use different language to describe these roles. Please respond keeping in mind the terms appropriate for your workplace.

GuardingMinds @ WORK

Please note: Your answers will be kept confidential.
This questionnaire takes 10 to 15 minutes to complete.

	4	3	2	1
1. My employer offers services or benefits that adequately address my psychological and mental health.				
2. All people in our workplace are held accountable for their actions.				
3. In my job, I know what I am expected to do.				
4. People treat each other with respect and consideration in our workplace.				
5. Hiring/promotion decisions consider the "people skills" necessary for specific positions.				
6. I receive feedback at work that helps me grow and develop.				
7. My immediate supervisor appreciates my work.				
8. I am able to talk to my immediate supervisor about how I do my work.				
9. The amount of work I am expected to do is reasonable for my position.				
10. I enjoy my work.				
11. My employer encourages me to take my entitled breaks (e.g., lunchtime, sick time, vacation time, earned days off, parental leave).				
12. My employer is committed to minimizing unnecessary stress at work.				
13. Management takes appropriate action to protect my physical safety at work.				
14. My supervisor would say or do something helpful if I looked distressed while at work.				
15. People at work show sincere respect for others' ideas, values and beliefs.				
16. Leadership in my workplace is effective.				
17. Our workplace effectively handles "people problems" that exist between staff.				
18. My company hires people who fit well within the organization.				
19. My supervisor is open to my ideas for taking on new opportunities and challenges.				
20. I am paid fairly for the work I do.				
21. I have some control over how I organize my work.				
22. I can talk to my supervisor about the amount of work I have to do.				

GuardingMinds @ WORK

Please note: Your answers will be kept confidential.
This questionnaire takes 10 to 15 minutes to complete.

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree
23. I am willing to give extra effort at work if needed.				
24. I am able to reasonably balance the demands of work and personal life.				
25. My immediate supervisor cares about my emotional well-being.				
26. My employer offers sufficient training to help protect my physical safety at work (emergency preparedness, safe lifting, violence prevention).				
27. I feel supported in my workplace when I am dealing with personal or family issues.				
28. Difficult situations at work are addressed effectively.				
29. I am informed about important changes at work in a timely manner.				
30. People from all backgrounds are treated fairly in our workplace.				
31. I have the social and emotional skills needed to do my job well.				
32. I have the opportunity to advance within my organization.				
33. My company appreciates extra effort made by employees.				
34. My opinions and suggestions are considered at work.				
35. I have the equipment and resources needed to do my job well.				
36. My work is an important part of who I am.				
37. My employer promotes work-life balance.				
38. My employer makes efforts to prevent harm to employees from harassment, discrimination or violence.				
39. When physical accidents occur or physical risks are identified, my employer responds effectively.				
40. My workplace supports employees who are returning to work after time off due to a mental health condition.				
41. I feel that I am part of a community at work.				
42. My supervisor provides helpful feedback on my performance.				
43. Unnecessary conflict is kept to a minimum in our workplace.				

GuardingMinds @ WORK

Please note: Your answers will be kept confidential.
This questionnaire takes 10 to 15 minutes to complete.

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree
44. My supervisor believes that social skills are as valuable as other skills.				
45. My company values employees' ongoing growth and development.				
46. Our organization celebrates our shared accomplishments.				
47. I am informed of important changes that may impact how my work is done.				
48. My work is free from unnecessary interruptions and disruptions.				
49. I am committed to the success of my organization.				
50. I can talk to my supervisor when I am having trouble maintaining work-life balance.				
51. I would describe my workplace as being psychologically healthy.				
52. I have the equipment and tools I need to do my job in a physically safe way (protective clothing, adequate lighting, ergonomic seating).				
53. People in my workplace have a good understanding of the importance of employee mental health.				
54. Employees and management trust one another.				
55. My organization provides clear, effective communication.				
56. My workplace has effective ways of addressing inappropriate behaviour by customers or clients.				
57. My position makes good use of my personal strengths.				
58. I have the opportunity to develop my "people skills" at work.				
59. My employer values my commitment and passion for my work.				
60. My employer encourages input from all staff on important issues related to their work.				
61. I have control over prioritizing tasks and responsibilities when facing multiple demands at work.				
62. I am proud of the work I do.				
63. I have energy left at the end of most workdays for my personal life.				

Please note: Your answers will be kept confidential. *This questionnaire takes 10 to 15 minutes to complete.*	Strongly Agree 4	Somewhat Agree 3	Somewhat Disagree 2	Strongly Disagree 1
64. My employer deals effectively with situations that may threaten or harm employees (e.g., harassment, discrimination, violence).				
65. My employer responds appropriately when workers raise concerns about physical safety.				

APPENDIX D

Search strategy developed for the systematic review.

PUBMED database was searched using the following strategy:

(fire-men OR fire-man OR firefighter OR firefighters OR firefighting OR fire-fighter OR "fire fighter" OR "fire men" OR "fire man" OR fire service) AND ("psychosocial stress" OR psycho-social OR "psychosocial stressors" OR "psycho-social stressors" OR "shift-work" OR "demand-reward imbalance" OR work life conflict OR stress OR stressors)

CINAHL database was searched using the following strategy: firefighters AND stress AND psychosocial

PsychINFO database was searched using the following strategy: firefighters AND stress AND psychosocial

Appendix E

Statistical models.

Correlation between AL score and GM@W final score. (used Poisson regression model for the fit)

```
Call:
glm(formula = ALscore ~ GM.W, family = poisson(), data = data6)

Coefficients:
(Intercept)         GM.W
  1.1490604    0.0002986

Degrees of Freedom: 5 Total (i.e. Null);  4 Residual
Null Deviance:     2.253
Residual Deviance: 2.252       AIC: 24.48
> fit1<-glm(ALscore~GM.W, family=poisson(),data=data6)
> summary(fit1)

Call:
glm(formula = ALscore ~ GM.W, family = poisson(), data = data6)

Deviance Residuals:
      1        2        3        4        5        6
 0.3679   0.8481  -0.8012  -0.1906   0.3437  -0.7755

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) 1.1490604  2.0941290   0.549    0.583
GM.W        0.0002986  0.0113191   0.026    0.979

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 2.2530  on 5  degrees of freedom
Residual deviance: 2.2523  on 4  degrees of freedom
AIC: 24.484

Number of Fisher Scoring iterations: 4
```

Correlation between PSS and AL score.

```
Call:
glm(formula = ALscore ~ factor(PSS), data = data6)

Deviance Residuals:
   1     2     3     4     5     6
 1.0   1.5  -1.5  -0.5   0.5  -1.0

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)     3.000      1.080   2.777   0.0691 .
factor(PSS)2    0.500      1.528   0.327   0.7649
factor(PSS)3    0.500      1.528   0.327   0.7649
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 2.333333)
```

```
    Null deviance: 7.3333  on 5  degrees of freedom
Residual deviance: 7.0000  on 3  degrees of freedom
AIC: 25.952

Number of Fisher Scoring iterations: 2
```

Correlation between AL score, PSS and GM@W.

```
Call:
glm(formula = ALscore ~ factor(PSS) + GM.W, data = data6)

Deviance Residuals:
      1        2        3        4        5        6
 1.1356   0.5508  -0.5508  -0.9068   0.9068  -1.1356

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  17.23729   15.06221   1.144    0.371
factor(PSS)2  4.11582    4.11952   0.999    0.423
factor(PSS)3  4.02542    4.03135   0.999    0.423
GM.W         -0.09040    0.09538  -0.948    0.443

(Dispersion parameter for gaussian family taken to be 2.415254)

    Null deviance: 7.3333  on 5  degrees of freedom
Residual deviance: 4.8305  on 2  degrees of freedom
AIC: 25.726

Number of Fisher Scoring iterations: 2


Linear regression btw age and AL score

Call:
lm(formula = ALscore ~ Age, data = data10)

Residuals:
      1       2       3       4       5       6
-0.1474  0.6200 -0.5192 -0.6047  1.4808 -0.8294

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.27078    1.69087   0.160    0.881
Age          0.07753    0.04157   1.865    0.136

Residual standard error: 0.9902 on 4 degrees of freedom
Multiple R-squared:  0.4652,   Adjusted R-squared:  0.3315
F-statistic: 3.479 on 1 and 4 DF,  p-value: 0.1356
```

Relationship between PSS and GM@W

```
> aov(PSS~GM.W, data=data6)

Call:
   aov(formula = PSS ~ GM.W, data = data6)

Terms:
                    GM.W Residuals
Sum of Squares  2.592430  1.407571
Deg. of Freedom        1         4

Residual standard error: 0.5932054
Estimated effects may be unbalanced
> ANOVA1=aov(PSS~GM.W, data=data6)
> ANOVA1

Call:
   aov(formula = PSS ~ GM.W, data = data6)

Terms:
                    GM.W Residuals
Sum of Squares  2.592430  1.407571
Deg. of Freedom        1         4

Residual standard error: 0.5932054
Estimated effects may be unbalanced

> summary(ANOVA1)
            Df Sum Sq Mean Sq F value Pr(>F)
GM.W         1  2.592  2.5924   7.367 0.0533 .
Residuals    4  1.408  0.3519
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> attributes(ANOVA1)
```

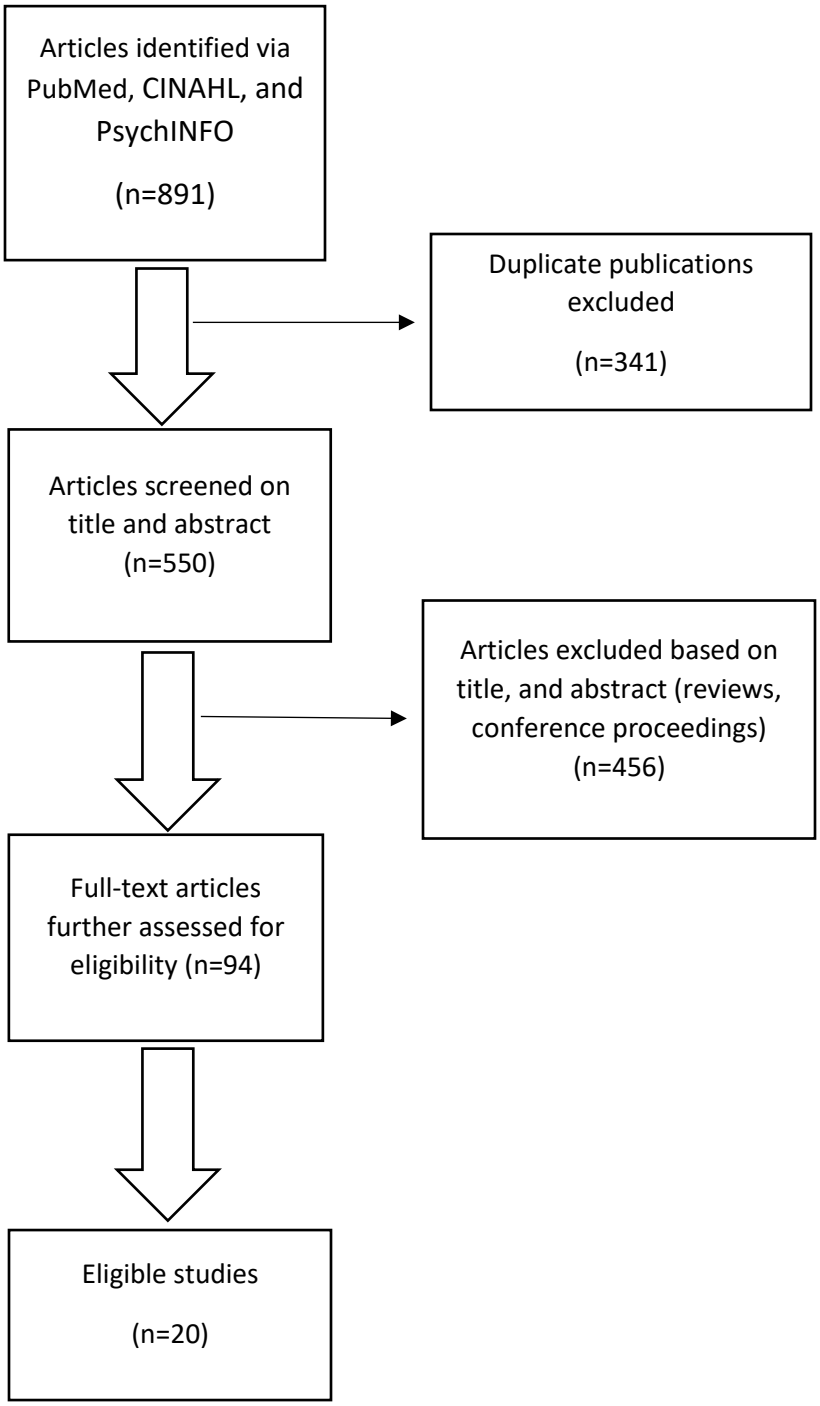

FIGURE 1. Flow chart for identification and screening of studies for systematic review.

Table 1. Characteristics and findings from studies measuring psychosocial stressors in firefighters

Author, year of publication	Location	Study Design	Sample Size	Psychosocial Stress Measurement Tool	Health Outcome	Results
An et al., 2015	South Korea	Prospective cohort study	186 Men	Korean Occupational Stress Scale-short form (KOSS-SF).	Behavioral and mental health disorders: depression	Risk of depression associated with organisational system (adjusted OR 8.03, 95% CI 1.73–37.22).
Angelo & Chambel 2013	Portugal	Longitudinal study *	1610 Men: 1449 Women: 161	Job Content Questionnaire (JCQ) Organizational demand scale	Behavioral and mental health disorders: burnout	Organizational demands have a significant positive cross-lagged effect on burnout ($p<0.05$). while burnout has a positive cross-lagged effect on organizational demands ($p<0.01$).
Barros et al., 2012	Brazil	Cross-sectional study	303 Men: 277 Women: 26	Lip Stress Symptom Inventory for Adults (LSSI)	Sleep disorders	Shift work was not significantly associated with sleep disorder ($p>0.05$)
Choi et al., 2016	USA	Cross-sectional study	330 Men: 321 Women: 9	FORWARD study questionnaire Job Content Questionnaire (JCQ) Effort-Reward Imbalance Questionnaire (ERIQ)	Cardiovascular disorders: hypertension	Additional sixteen 24-h shifts were significantly associated with 5.0 mmHg higher DBP ($p < 0.01$). Increased job demands "over the past year" lead to a significantly ($p = 0.06$) higher systolic blood pressure.
Damrongsak et al., 2017	USA	Cross-sectional study	298 Men	The Job Stress Survey (JSS) The Job Satisfaction Survey (JOBSAT) The Contents of Communication Scale (COCS)	Musculoskeletal Disorders: back pain	Occupational stress (stress severity, job pressure, organizational support and stress frequency) was a significant predictor of current back pain ($p<0.0001$).

Haddock et al., 2013	USA	Cross-sectional study *	458 Men	Perceived Stress Scale (PSS) Occupational History survey	Sleep disorders: excessive daytime sleepiness	On-duty EDS was significantly associated with 48-hour shifts (*P*=0.039). Off-duty EDS was significantly associated with a second job outside the fire-service (P=0.043).
Hosoda et al., 2012	Japan	Cross-sectional study	294 Men	Brief Job stress questionnaire	Behavioral disorders: alcohol abuse	Multivariate analysis showed a significant relationship between alcohol dependence (AUDIT scores) and workplace environment (r=0.140, p=0.047), and rewarding work (*r* =0.161, *P* = 0.011).
Jang et al., 2016	South Korea	Cross-sectional study	1217 Men: 1140 Women: 77	Korean Occupational Scale (KOSS)	Gastrointestinal disorders: GERD	GERD risk was associated with: job demand (OR: 1.83, 95% CI: 1.34–2.51), interpersonal conflict (OR: 2.07, 95% CI: 1.06–3.51), lack of reward (OR: 2.17, 95% CI: 1.21–3.88), and occupational climate (OR: 1.49, 95% CI:1.09-2.02).
Jang et al., 2017	South Korea	Cross-sectional study	1217 Men: 1140 Women: 77	Korean Occupational Scale (KOSS) Ways of Coping Checklist (WCCL)	Gastrointestinal disorders: IBS	IBS risk was significantly associated with job demand (OR 1.79, 95% CI: 1.11–2.89), interpersonal conflict (OR 2.21, 95% CI: 1.25–4.33), organizational system (OR 1.87, 95% CI: 0.58–3.30), lack of reward (OR 2.39, 95% CI: 1.08–5.26).
Kim et al., 2013	South Korea	Cross-sectional study	21466 Men	Korean Occupational Stress Scale (optional KOSS-26)	Musculoskeletal disorders: back pain	WMSD associated with physical environment (OR 2.22, 95% CI,1.96 - 2.53); job demand (OR 1.52, 95% CI,1.35 - 1.70); job insecurity (OR 1.14, 95% CI,1.01 - 1.28); organizational system (OR 1.37, 95% CI,1.21 - 1.58); lack of reward (OR 1.15, 95% CI,1.01 - 1.31); occupational climate (OR 1.24, 95% CI,1.11 - 1.40) after adjusting for

						depression and general work characteristics.
Kim et al., 2016	South Korea	Cross-sectional study	24209 Men	Korean Occupational Stress Scale – Short Form (KOSS-SF)	Musculoskeletal disorders: back pain	LBP was associated with psychosocial stressors in middle and high stress groups compared with the low stress group: uncomfortable physical environment (MT: *OR* 1.36, 95% CI, 1.17-1.58; UT: *OR* 1.73, 95% CI,1.58-2.14); high job demand (MT: *OR* 1.29, 95% CI, 1.13-1.37; UT: *OR* 1.55, 95% CI,1.35-1.77); and organizational injustice (UT: *OR* 1.53, 95% CI, 1.04, 2.24). inadequate Social support was inversely associated with LBP (MT: *OR* 0.81, 95% CI, 0.69-0.94; UT: *OR* 0.84, 95% CI, 0.72- 1.00).
Lim et al., 2014	South Korea	Cross-sectional study	657 Men	Korean Occupational Scale-Short Form (KOSS-SF). Psychosocial Well-Being Index-Short form	Sleep disorders	Poor sleep quality was associated with: job demand ($p = 0.001$), insufficient job control ($p = 0.001$), job insecurity ($p = 0.030$), organizational system ($p < 0.001$), lack of rewards ($p < 0.001$), occupational climate ($p < 0.001$).
Meyer et al., 2012	USA	Cross-sectional study	142 Men: 141 Women: 1	The Sources of Occupational Stress (SOOS) The Interpersonal Support Evaluation List (ISEL)	Behavioral and mental health disorders: PTSD, alcohol abuse	Individuals belonging to low social- support and high-blame group were significantly likely to report PTSD symptoms on both CAPS ($p=0.009$) and PCL-C ($p<0.001$) and likely to report probable alcohol abuse on the CAGE questionnaire ($p<0.001$).
Mitani et al., 2006	Japan	Cross-sectional study	243** Men: 237 Women: 4	Japan Brief Job Stress Questionnaire	Behavioral and mental health disorders: burnout, PTSD	Social support negatively associated with emotional exhaustion (r -32, $p<0.01$) and depersonalization (r-0.36, $p<0.01$) of burnout subscales. Lower social support ($p=0.001$) and self-administered job-stress ($p=0.003$)

						significantly associated with high PTSD group.
Regehr et al., 2003	Canada	Cross-sectional study	123 Men	Social Provisions Scale (SPS)	Behavioral and mental health disorders: depression	Higher depression scores associated with decreased perceived support from friends (r = -0.34, p =0.01), and from family (r = -0.32, p =0.01).
Saijo et al., 2007	Japan	Cross-sectional study	1672 Men: 1626 Women:46	The National Institute for Occupational Safety and Health (NIOSH) generic job questionnaire (Japanese version)	Behavioral and mental health disorders: depression	High variance in workload (vs. low: OR 2.05, 95% CI 1.29–3.25), high intergroup conflict (vs. low: OR 1.91, 95% CI 1.26– 2.88), high role conflict (vs. low: OR 1.87, 95% CI 1.24–2.80), and low self-esteem (vs. high: OR 5.78, 95% CI 3.93–8.50) had significantly higher ORs for depressive symptoms.
Saijo et al., 2008	Japan	Cross-sectional study	1301 Men: 1209 Women: 92	The National Institute for Occupational Safety and Health (NIOSH) generic job questionnaire (Japanese version)	Behavioral and mental health disorders: depression	Depressive symptoms associated with high variance in workload (OR 2.08 CI 95% 1.22-3.56), high intergroup conflict (OR 1.70, CI 95% 1.92-2.85), high role ambiguity (OR 1.63, CI 95% 1.04-2.56), role conflict (OR 1.64, CI 95% 1.06-2.53) and low self-esteem (OR 5.16, CI 95%3.32-8.01).
Saijo et al., 2012	Japan	Cross-sectional study	1667 Men: 1621 Women: 46	The U.S. National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire (Japanese version)	Behavioral and mental health disorders: PTSD	After adjustment for age and gender, PTSD-positive group scored significantly higher for inter-group conflict (p=0.037), role ambiguity(p=0.002), and low social support from supervisors (p=0.019).
Shin et al., 2016	South Korea	Cross-sectional study	645 Men	Korean Occupational Scale (KOSS)	Cardiovascular disorders: heart rate variability	Decrease in HRV significantly associated with organizational system and occupational climate of the group with high stress (p = 0.034, p =

						0.043, respectively) after adjusting for sociodemographic and job characteristics.
Tak et al., 2007	USA	Cross-sectional study *	525 Men: 504 Women: 21	No validated questionnaire.	Behavioral and Mental health disorders: Depression	Depressive symptoms significantly associated with dissatisfaction with supervisory support (PR=1.6; 95% CI: 1.1, 2.3).

Abbreviations: AUDIT, Alcohol Use Disorders Identification Test; CAPS, Clinician-Administered PTSD Scale; DBP, diastolic blood pressure; EDS, excessive daytime sleepiness; GERD, gastroesophageal reflux disease; HRV, heart rate variability; IBS, irritable bowel syndrome; LBP, lower back pain; OR, odds ratio; PCL-C, PTSD Checklist-Civilian; PR, prevalence ratio; PTSD, post-traumatic stress disorder; WMSD, work-related musculoskeletal disorder.

Note: * indicates poor quality studies, i.e., used a non-validated questionnaire to measure psychosocial stress. ** data about the gender of two participants was not available according to the authors.

Table 2. Summary of biomarkers used to calculate allostatic load index.

Group	Type	Biomarker	Description
Primary mediators	Neuroendocrine	Cortisol (hair)	A glucocorticoid produced in the cortex of the adrenal gland. This steroid hormone serves as an indicator for HPA-axis activity.
Secondary mediators	Cardiovascular	Systolic blood pressure	Serves as a measure of intravascular pressure at the end of left ventricular contraction.
		Diastolic blood pressure	A measure of intravascular pressure at the end of left ventricular relaxation.
	Metabolic	Low density lipoprotein	A cardio-destructive form of cholesterol. Transports cholesterol from liver to peripheral tissues. A measure for atherosclerotic risk.
		High density lipoprotein	Carries cholesterol from peripheral tissues to the liver (cardioprotective). Also, a measure for atherosclerotic risk.
		Triglycerides	Cardio-damaging type of fat.
		Glycosylated hemoglobin	Indicates a three-month average of blood glucose concentration. Sign of blood glucose regulation
Tertiary outcomes	Metabolic	Body Mass Index	Kg/m^2. A measure of obesity based on weight and height.
		Waist-to-hip ratio	Measures adipose tissue deposits based on ratio of waist circumference to hip circumference. A measure of abdominal obesity.

Table 3. Characteristics of the participants (n = 6).

	Number	%
Age		
20 ~ 34	3	50.00
35 ~ 49	1	16.67
50 ~ 65	2	33.33
Gender		
Male	6	100
Alcohol intake		
2-3 times a month	2	33.33
Once a week	1	16.67
2-3 times a week	1	16.67
4-6 times a week	2	33.33
Respiratory Symptoms		
Yes	1	16.67
No	5	83.33

Table 4. Responses to the perceived stress scale

Participants	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	PSS Score
1	3	1	2	4	3	0	4	3	1	0	11
2	4	3	3	3	2	3	2	2	4	3	25*
3	3	3	3	2	2	2	2	2	3	3	21*
4	2	1	3	3	2	1	3	3	3	2	19*
5	2	2	3	3	2	1	2	2	2	2	19*
6	1	3	3	0	1	0	1	1	1	0	11

The PSS range of scores falls between 0-40. Scores ranging from 0-13 ~ low stress, 14-26 ~ moderate stress, and 27-40 ~ high perceived stress. Note. (*) indicates participants with a moderate degree of perceived stress.

Table 5. Responses to the GM@W questionnaire.

Participants	**PF 1**	**PF2**	**PF3**	**PF 4**	**PF 5**	**PF 6**	**PF 7**	**PF8**	**PF9**	**PF 10**	**PF 11**	**PF 12**	**PF 13**	**TOTAL**
1	12	9	8	13	14	10	14	10	13	14	15	14	13	159
2	15	12	12	13	15	16	16	13	14	19	15	9	17	186
3	16	14	13	16	15	18	14	16	15	20	16	15	19	207
4	15	11	12	13	15	15	17	14	15	20	17	15	14	193
5	16	13	12	16	15	14	16	14	15	20	17	17	17	202
6	10	9	10	13	11	12	15	12	9	10	17	15	13	156
AVERAGE	**14.00**	**11.33***	**11.17***	**14.00**	**14.17**	**14.17**	**15.33**	**13.17***	**13.50***	**17.17**	**16.17**	**14.17**	**15.50**	

The averages of the 13 psychosocial stressors are included. Responses to each psychosocial category are scored as follows: serious concern = 5-9, significant concerns = 10-13, minimal concern = 14-16, and relative strength= 17-20. Note, the (*) represents psychosocial factors where individuals reported "significant concern".

PF1- Psychological support; **PF2** – organizational structure; **PF3** – clear leadership and expectations; **PF4** – civility and respect; **PF5** – psychological competencies and requirements; **PF6** – growth and development; **PF7** – recognition and reward; **PF8** – involvement and influence; **PF9** – workload management; **PF10** – engagement; **PF11** – balance; **PF12** – psychological protection; **PF13** – protection and physical safety.

Table 6. Summary of allostatic load measurement

Allostatic load Variables (Unit)	**Mean (S.E.M.)**	**Range**	**Cut offs**	**Clinical reference**
Cortisol (ng/g)	180.82 (114.49)	39.55-365.40	≥64.7	31.1-75.9
Systolic blood pressure (mmHg)	134.00(13.42) *	119-153	≥127.50	90-140
Diastolic blood pressure (mmHg)	81.17(12.88)	66.5-102.5	≥82.50	60-90
Glycosylated hemoglobin (%)	5.07(0.23)	4.8-5.3	≥5.80	4.60-6.20
High density lipoprotein (mmol/L)	1.27(0.20)	1.03-1.59	≤1.18	0.9-2
Low density lipoprotein (mmol/L)	2.21(0.50)	1.46-2.92	≥3.7	2.59-4.12
Triglycerides	1.32(0.82)	0.5-2.83	≥1.45	0.4-1.8
Body mass index (kg/m^2)	27.65 (1.71) *	25.95-30.33	≥23.375	18.5-25
Waist-to-hip ratio	0.93(0.06)	0.86-1.02	≥0.95	0.8-1
Allostatic load	4.17 (1.72)	2-6		

Note. (*) indicates means that were greater than their respective cut-offs.

Table 7. Pearson's correlation between single allostatic load parameters and relation to age and both questionnaires

	HairCort	**BMI**	**WHR**	**Systolic**	**Diastolic**	**LDL**	**HDL**	**TRGL**	**HBA1c**	**AGE**	**PSS**
BMI	0.48 (0.34)										
WHR	0.27 (0.61)	0.64 (0.17)									
Systolic	0.57 (0.23)	0.5 (0.31)	0.20 (0.71)								
Diastolic	0.47 (0.35)	**0.94 (0.01)***	0.61 (0.20)	0.61 (0.20)							
LDL	0.33 (0.53)	0.32 (0.54)	0.27 (0.60)	0.08 (0.87)	0.32 (0.53)						
HDL	0.11 (0.83)	0.51 (0.30)	0.68 (0.14)	0.07 (0.90)	0.54 (0.27)	0.68 (0.14)					
TRGL	0.01 (0.98)	0.31 (0.56)	0.04 (0.94)	0.47 (0.35)	0.34 (0.51)	0.76 (0.08)	0.68 (0.14)				
HBA1c	0.69 (0.13)	0.10 (0.84)	0.02 (0.97)	0.14 (0.79)	0.08 (0.88)	0.63 (0.18)	0.49 (0.32)	0.65 (0.16)			
AGE	0.59 (0.27)	0.695 (0.13)	**0.95 (0.003)***	0.02 (0.97)	0.69 (0.13)	0.42 (0.41)	0.57 (0.23)	0.09 (0.86)	0.24 (0.65)		
PSS	**0.87 (0.02)***	0.27 (0.60)	0.19 (0.72)	0.66 (0.15)	0.21 (0.68)	0.25 (0.63)	0.25 (0.63)	0.01 (0.98)	0.66 (0.15)	0.09 (0.86)	
GM@W	0.49 (0.33)	0.19 (0.72)	0.56 (0.24)	0.37 (0.46)	0.30 (0.56)	0.25 (0.64)	0.34 (0.51)	0.17 (0.75)	0.37 (0.47)	0.39 (0.44)	0.79 (0.06)